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SEPTEMBER
1930

HUMAN BIOLOGY

a record of research

Vol 2 No 3

Published Quarterly by Warwick & York, Inc.
29 EAST CENTER STREET BALTIMORE, MARYLAND U.S.A.

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HUMAN BIOLOGY is published quarterly by Warwick and York, Inc., Baltimore, Md. The advance subscription price is $5.00 a year; foreign postage 40 cents extra. Single current issues are $1.50 each; back numbers, $2.00 each; back volumes $6.00; plus postage. Subscriptions for less than a year are charged at the single issue price.

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Manuscripts and cummunications regarding editorial matters should be addressed to Editor, Human Biology, Department of Biology, School of Hygiene and Public Health, 1901 E. Madison St., Baltimore, Md., U. S. A.

WARWICK AND YORK, INC.

Publishers · BALTIMORE, MD.

Entered as Second Class matter, February 13, 1929, at the Post Office at Baltimore, Md., under the Act of March 3, 1879; also additional entry as Second Class matter at York, Pa.

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Vol. II No. 3

HUMAN BIOLOGY

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SEPTEMBER, 1930

THE SKELETON OF THE TRUNK AND LIMBS OF HIGHER PRIMATES

BY ADOLPH H. SCHULTZ

Laboratory of Physical Anthropology, Johns Hopkins University

INTRODUCTION

During the last few years the Laboratory of Physical Anthropology of the Johns Hopkins University obtained the complete skeletons of twelve gorillas. It seemed desirable to describe this valuable series in detail so that it would become available to other investigators. It soon became apparent, however, that the mere recording of individual variations in one limited group of apes could produce but few answers to the many tantalizing questions arising from the study of the skeleton of that ape which most closely resembles man. The original plan grew by degrees into a research program for comparative studies on all the recent higher primates, including the gibbon, the siamang, the three large apes, and man. For this comprehensive purpose various other collections had to be visited. In these the author found such a wealth of material, of which the largest part had never before been used for an investigation of this nature, that he was confronted with the alternative of studying either only a few of all the available specimens, but these in full detail, or else all the extensive series, but only in regard to the main features. The latter course was adopted for a number of reasons. It had been found that the higher primates vary individually to such a degree that numerous specimens are indispensable for reliable definitions of the typical and average conditions of most skeletal characters. Furthermore, this remarkable variability is in itself of great significance in the investigation of

phylogenetic relationships between different primates. It seems particularly important to determine the ranges of individual variations within a species or genus and the degree to which these ranges approach one another or even overlap.

This particular consideration of variations was possible only at the expense of the number of characters observed. Thus it was decided to leave out for the time being all observations appertaining to the skull. The skulls of apes and man have been investigated in far greater detail than have the other skeletal parts, and papers dealing with cranial features are much more numerous than those treating of the bones in the trunk and limbs. The classification of primates is to a very large extent based upon teeth and skulls, whereas the skeleton of trunk and limbs has been used comparatively little for taxonomic purposes. There exists no good reason for this arbitrary neglect of one group of structures in favor of some other structures, except perhaps the fact that skulls are being collected with much greater frequency than are entire skeletons. It will be shown in this paper that the bones of the trunk and limbs can be of special taxonomic value in cases in which the skulls of two species or genera were not significantly different. For instance, the elaborate recent revision of the genus *Gorilla* by Coolidge (1929) led to the conclusion that the mountain gorilla represents merely a subspecies. This view, however, is based exclusively upon the examination of adult male skulls. In a former paper (1927) on growth and body proportions the writer discussed a number of differences between the mountain gorilla and the West-African gorillas. The present study of skeletal structures adds several new and significant differences, strengthening the conviction that the mountain gorilla fully deserves the rank of a species. For similar reasons the author can not agree with the recent conclusion of Kloss (1929) that the siamang is merely the largest species of the genus *Hylobates*, even though the skull of siamang is little different from that of the true gibbon species. As will be shown later, the pelvis, sternum, limb bones, etc., of siamang differ from those of gibbons much more than these structures differ between any two species of *Hylobates*. Any valid classification must rest upon the examination of many different structures, particularly in cases in which the skulls alone showed only similarities.

The reliability and value of any discussion of variations increase in proportion to the number of specimens considered. For this reason it is but natural that published reports on other primate material

should be included in the statistics of this study, so that all available and comparable data will be collected in one paper. This search of the literature, which is not claimed to be absolutely complete, proved to be a difficult task for three reasons. First of all, many authors failed to give adequate definitions of the particular features observed or omitted to state the exact methods of their measuring. For instance, some writers mentioned that in their opinion a last lumbar vertebra, touching with its broadened transverse processes the *ilia*, might be regarded as a sacral vertebra; but it is not evident whether or not they followed this suggestion in the actual count of vertebrae. Other authors recorded the "length of the femur," sometimes even in tenths of millimeters, but forgot to give the very essential information whether the measurement was taken from the great trochanter or from the head of the femur. Unfortunately, all such reports are practically useless for comparative purposes. In the second place, the older literature, in particular, contains a great many papers on primates with antiquated or even impossible names of species, and not infrequently one gathers a well-founded suspicion that a particular animal was wrongly identified even in regard to its genus. In some instances it is possible to translate the old name into modern nomenclature or to correct an erroneous identification in cases in which the animal had been accurately described or pictured in an accompanying illustration, but in many other cases this proves to be a hopeless undertaking. For instance, the recent monograph by Boltze (1926) on the gibbon skeleton gives even in the title the species as "*Hylobates syndactilus*" (which should have read: *Symphalangus syndactylus*), but a careful study of this detailed paper proves beyond any doubt that Boltze's species determination was wrong and that he never had any siamangs. Finally, the third reason for disregarding a considerable number of reports lies in the fact that frequently it is uncertain whether an author obtained his information from his own observations or merely from some other paper. Even if it were his own observation one could not always decide whether or not it were based upon a specimen previously used for the same purpose by some other author, so that one would be apt to include repeatedly in variation statistics one and the same specimen under the names of different authors. Some papers contained sufficient circumstantial evidence for the safe distinguishing between the author's new data and those taken over from previous papers. This failure to give in detail the source of all the specimens examined is particularly regrettable in the case of the famous paper

by Keith (1903) on the numerical variations in vertebrae of higher primates. The data of this study are more extensive than those of any other single paper published up to the present time. They would have formed a most welcome basis to which to add the writer's own observations. However, Keith merely states that his data are from three sources: "(1) from publications by many authors; (2) from personal dissections; (3) from the material in the museums of London." That it is impossible to calculate the number of his own and original data, not derived from previous literature, is shown by the following example: Keith tabulates the numbers of presacral vertebrae in a total of 27 gorillas, but the writer collected the corresponding data for 50 gorillas alone from the literature prior to 1903.

The laborious task of a critical survey of the literature has determined the author to record in detail all the data which he has sifted from the mass of published reports. Similarly, it seems absolutely necessary to report the author's new data together with all information in regard to the collection, catalogue number, sex and age of the specimens studied. Only in this way will future research workers be enabled to add directly their new observations to the present tabulations or to use the individual records of this paper for new interpretations.

The main purpose of the varied collection of facts, embodied in this study, is to contribute new evidence for the reconstruction of the primate family tree and, particularly, of the exact place thereon of the human branch. The most recent publications by Keith (1927), Gregory (1928), Miller (1929), Osborn (1927, 1930), Wood Jones (1929), and others demonstrate strikingly that man can not yet be assigned a definite place among primates without its being challenged by some differing claims deserving thorough consideration. This is not the place in which to review the data produced in support of the many conflicting conclusions in regard to man's relationship to other primates. Anyone who has worked on this task will admit that so far only a few of the many possible attacks on this fascinating problem have been carried out in an exhaustive manner. The kind of available evidence, therefore, still varies a great deal in bulk and importance. Physiological contributions, for instance, are still insignificant alongside of the mass of morphological findings, and the latter are very unevenly distributed among the different specialties.

This study of the skeleton with its special emphasis on variations is intended to fill one of the many gaps in our knowledge of a field of

science that has been comparatively neglected. Since only the skeleton, and that of recent primates alone, has been investigated, the direct results can bear only upon the degrees of resemblance among different primates and the relative amounts of their specializations. Indirectly, however, the findings will justify some hypothetical conclusions in regard to the phylogenetic relationships between man and other recent primates. The individual proportions of various skeletal parts have been tabulated in detail not only to illustrate the tendencies in different recent primates to vary but also in order to render them available for future comparative studies on fossil primates.

MATERIAL

The observations, discussed in this paper, are based chiefly upon the skeletons of higher primates, of which as many specimens as were accessible have been used. Only in the case of man—the best-known higher primate—was the investigation of most features limited to the material in the author's laboratory. Wherever necessary a few random samples of lower primates were examined in order to provide an approximate scale by which to evaluate the differences between the higher primates.

Not all observations could be taken on equally large series of cases. Some of the skeletons were not complete, parts having become lost, such as the coccyx, or having been shattered by bullets. A surprising number of skeletons collected in the field showed unmistakable signs of disease, particularly in joints, or of localized injuries, affecting most commonly the long bones of the limbs,[1] but also at times the vertebrae and the pelvis. Some of the measurements on the pelvis and the scapula were taken on comparatively few specimens, because the measuring technique called for more time and apparatus than were at the disposal of the author during his visits to some of the museums. A considerable number of foot skeletons could unfortunately not be utilized because they had already been disarticulated and mixed in one box with the bones of the hands, so that the measurement of the tarsus length would not be reliable and the identification of some of the phalanges could not be absolutely safe.

The material from the Laboratory of Physical Anthropology of the Johns Hopkins University and that in the author's private collection was used most exhaustively and served for the majority of the illustrations. It may here be mentioned that the gorilla series of the former collection contains what seems to be the largest gorilla skeleton ever described (P. A. L. 8). The length of its humerus, *e. g.*, measures 480 mm. (see table XIX), which surpasses the maximum of 478 mm. previously recorded by Fick (1926). The sternum without the xyphoid process is 247 mm. long, the nearest value in another gorilla being only 221 mm. (see table XI). In spite of this huge body size, as indicated by most of the skeletal dimensions, the cranial capacity amounts to only 485 cu. cm. Of the eleven West-

[1] Old fractures of limb bones and ribs are particularly common in orang-utans. The surprising capacity for extensive bone repair in anthropoid apes is clearly demonstrated by the example of the gorilla skeleton described by Holland (1924). All these diseased or injured bones were excluded from the series of measurements.

African gorillas in the Laboratory of Physical Anthropology the Nos. 1, 2, and 3 came from Spanish Guinea and all the others from Cameroon. The young female mountain gorilla (P. A. L. 7) of this laboratory was sent to the author immediately after its death. The skeleton was still completely articulated and was accompanied by the fresh skin which contained the phalanges. This animal, known as "Congo," had been captured alive in the Kivu mountains by Mr. B. Burbridge. The skeleton and skin were most generously donated to the writer by "Congo's" last owner, Mr. J. Ringling.

Among the other material, used for this paper, special mention should also be made of the splendid collections of more or less complete orang-utan skeletons, numbering 31 specimens in the U. S. National Museum, and 15 specimens in the Wistar Institute of Anatomy. A total of 159 different specimens of higher primates (without man) and of 61 different lower primates were utilized for the new data of this study. They are listed individually in a number of the tables. The observations on the relatively few specimens from European collections are from notes by the author made many years ago. Some data in regard to the number of vertebrae were obtained from mounted skeletons in museum exhibits and some few others from X-ray photographs or partial dissections of preserved specimens. The entire material belongs with a few isolated exceptions to the museums and other institutions listed below in the approximate order of the number and importance of the specimens studied at each place. Later tables contain the names of these museums etc. merely in the abbreviated form given here in parentheses.

U. S. National Museum (Nat. M.)
American Museum of Natural History (Amer. M.)
Wistar Institute of Anatomy and Biology (Wist. I.)
Laboratory of Physical Anthropology, Johns Hopkins University (P. A. L.)
Collection of A. H. Schultz (Sch.)
Department of Anatomy, Johns Hopkins University (A. Hopk.)
Department of Anatomy, Western Reserve University (W. R. U.)
Philadelphia Academy of Natural Sciences (Ph. Acad.)
Zoologisches Institut, Universität Zürich (Zo. I. Z.)
Field Museum of Natural History (Field M.)
Musée d'anatomie comparée, Paris (M. a. c. P.)
Department of Anatomy, Jefferson Medical College (A. Jeff.)
Department of Zoology, Columbia University (Zo. Col.)
Army Medical Museum (Army M.)

For the generous permission to examine the valuable material in these institutions the author is particularly indebted to Mr. G. S. Miller, Jr., Prof. W. K. Gregory, Dr. J. M. Greenman, Dr. W. Stone, and Prof. K. Hescheler. The writer is also indebted to his colleague, Dr. W. L. Straus, Jr., who has kindly placed at his disposal data appertaining to the length of the limb bones of 6 gorillas and 1 chimpanzee in the collection of Western Reserve University and of 15 human skeletons in the University of Maryland. In addition Dr. Straus has contributed more or less complete data on the number of vertebrae in 2 gorillas, 1 chimpanzee and 1 gibbon from the former collection and in 66 negroes from both the just mentioned universities as well as in part from the Johns Hopkins University. These observations had been made by Dr. Straus with the generous permission of Prof. T. W. Todd and of Prof. C. L. Davis.

All the species names of primates, as used in this paper, are according to Elliot (1913). No subspecies are given, since to do this would have split the various series into too small groups, and also because many of the proposed subspecies appear to the author as extremely doubtful forms which, in the absence of more material, are better regarded as individual variations. In the chimpanzee not even the species have been named since their identification from the skeleton alone is in most cases at best very uncertain. This genus is very much in need of a revision, since few authorities agree in regard to the number of species it contains, and even in regard to the value of the distinguishing characters themselves. The same may be said in reference to the genus *Hylobates* (see *e. g.* Pocock, 1927, and Kloss, 1929), which most likely does not consist of as many really justifiable species as are listed by Elliot. The genus *Pongo* has by a number of authors been divided into two species and many subspecies. For the proper evaluation of some of the findings discussed in this paper, it is necessary to emphasize here that there exists no reasonable justification for the separation between the Bornean and the Sumatran orang-utans. Lyon (1911), for instance, who recognizes two species, himself says that "In fact, it is with great difficulty that I have been able to find any tangible differences between the orangs of northern Sumatra and those from western Borneo." Elliot (1913), after extensive investigations, reached the opinion that there is only one species of this great ape, *i. e.*, *Pongo pygmaeus*. The same conclusion has recently been published by Brandes (1929) who has had exceptional opportunities for studying large numbers of living captive orangs. The writer found from his unpublished investigations on the preserved bodies of 22 orangs that such supposed species characters as size, proportions, and presence or absence of cheek callosities and of nails on the great toes vary individually in an astonishing degree. The nail of the hallux, for instance, was in two specimens well developed on one foot but congenitally missing on the other foot. For these, as well as for certain other reasons, the author is thoroughly convinced that no constant species differences can be demonstrated in the genus *Pongo*.

SPINAL COLUMN

The observations on the spinal column are restricted to the number of vertebrae in the various regions. No measurements were taken except on the sacral vertebrae. These will be discussed in the chapter on the pelvis. A few remarks are necessary concerning the characterization of the different types of vertebrae. The material examined caused no difficulty in regard to the cervical vertebrae since not a single case was encountered with a deviation from the normal number of seven. Only two instances were found in the literature, in which there were eight cervical vertebrae in apes. These are a gorilla described by Struthers (1893) and a siamang described by Kohlbrügge (1891). An actual reduction in number has never been reported, except for man, but a fusion of two or more cervical vertebrae was observed by the author in two gorillas, two orangs, and one chimpanzee and has been described by Meyer (1915) in a gorilla. It is on account of this

pronounced constancy in regard to their number that the cervical vertebrae have neither been tabulated nor will be further discussed in this paper.

All vertebrae bearing ribs have been counted as thoracic vertebrae. In the relatively few cases in which there is a rib only on one side of the last thoracic vertebra, the other side possessing a true transverse process, this vertebra was counted as half of one, the other half being added to the lumbar series. In four instances the last and very short rib of one side was completely fused with the vertebra, giving it the appearance of a transition vertebra, as which, however, it was not counted.

In ape skeletons it is sometimes difficult to distinguish in a consistent manner between the last lumbar and the first sacral vertebra, unless one adheres strictly to the following definition of the sacrum: Only such vertebrae are sacral ones as unite not only with their bodies but also with their lateral masses, so that the number of sacral vertebrae always exceeds by one that of the real sacral foramina on one side. This leaves no doubt that the writer did not include among sacral vertebrae such last lumbar vertebrae which may reach the ilia with their broadened transverse processes, as *e. g.* in the *Symphalangus* shown in figure 12. The material studied happened to contain no case of a well defined lumbosacral vertebra, in which a true sacral foramen was formed on one side only, the opposite side bearing merely a lumbar transverse process.

Guided by the above definition of the sacrum one can readily decide where the coccygeal vertebrae begin. Quite frequently some of these small bones are fused, causing some doubt in regard to their actual number. In seven cases there were two separate ossicles side by side at the lower end of the coccyx. These were counted as only one vertebra, because in a few other cases the last coccygeal vertebra was not completely divided in the mid-line but was merely forked.

The individual vertebral formulae are listed in the tables I to X at the end of this paper. Besides all the cases of gibbons, siamangs and anthropoid apes these tables contain the data for four series of lower primates. The latter are merely samples for general comparative purposes; they represent the only four different genera for which an adequate number of data happened to be available. The vertebral formulae of man are the only ones not listed individually, since data for man have already been published in so many papers that the new contribution by the author, based on a total of only 72 different individuals, is not of sufficient interest to warrant a separate enumeration.

Thoracic Vertebrae

The number of thoracic vertebrae varies in different primate genera as well as in individuals of the same species to a considerable extent. Among the *Simiae* this number ranges from 11 to 15 and among the *Prosimiae* from 12 to 17. The maximum number of 17 was apparently found but once, namely by Flower (1888) in a *Loris javanicus*. This prosimian genus *Loris* (*"Stenops"*) seems to have

the highest average number of thoracic vertebrae since various authors (see Ranke, 1897) have reported 14 to 16 vertebrae for different species of this genus. Even among prosimians, however, there are already several genera containing species with only 12 thoracic vertebrae. Platyrrhine monkeys possess 12 to 15 segments in the thoracic region of the spine, the number 12 occurring rarely, namely only in two specimens of *Callithrix* (Ranke, 1897) and in two specimens of *Cebus* (Flower, 1862, and Ranke). It is not yet possible to state the typical

TABLE 1

Percentage Distribution of Variations and Averages of the Number of Thoracic Vertebrae in Primates. The Data for Man Are Calculated from the Figures in Table 2

PRIMATE	TOTAL OF CASES	NUMBER OF THORACIC VERTEBRA								AVERAGE
		11	11½	12	12½	13	13½	14	15	
Cebus	37			5.4		13.5		*70.3*	10.8	13.9
Ateles	20					10.0		*90.0*		13.9
Alouatta	24					16.7		*70.8*	12.5	14.0
Pithecus	50			*92.0*		8.0				12.1
Hylobates	57			15.8		*75.4*		8.8		12.9
Symphalang. syndactylus	16			12.5		*87.5*				12.9
Hylobatidae	75			14.7		*78.7*		6.6		12.9
Pan	55			12.7	1.8	*74.6*	1.8	9.1		13.0
Gorilla gorilla	75			5.3		*86.7*		8.0		13.0
Gorilla beringei	7			42.9		*57.1*				12.6
Gorilla	82			8.5		*84.2*		7.3		13.0
Pongo pygmaeus	79	12.7	6.3	*72.1*	1.3	7.6				11.9
Homo (Negroes)	161	5.0		*91.3*		3.7				12.0
Homo (Japanese)	429	0.2	0.5	*96.0*	0.7	2.6				12.0
Homo (Whites)	766	2.1	0.1	*94.0*	0.1	3.7				12.0
Homo sapiens	1356	1.8	0.2	*94.4*	0.3	3.3				12.0

number of these vertebrae in most of the lower *Simiae*, since the series of specimens observed are with few exceptions entirely insufficient in view of the marked variability of this feature. In the three platyrrhine genera of the family *Cebidae*, listed in table 1, all had on a rough average 14 thoracic vertebrae, but individual reductions in this number are more frequent than variations in the opposite direction. Adequate

TABLE 2

The Number of Thoracic Vertebrae in Different Human Races According to Various Reports in the Literature and Considering Also the Author's New Series of Negroes

AUTHOR	RACE	TOTAL OF CASES	NUMBER OF THORACIC VERTEBRAE				
			11	11½	12	12½	13
Trotter, 1929	Negro	97	5		90		2
Schultz	Negro	64	3		57		4
TOTAL OF NEGROES		161	8		147		6
Hasebe, 1913	Japanese	181		2	168	3	8
Kubo (Hasebe)	Japanese	100	1		96		3
Nishi, 1928	Japanese	148			148		
TOTAL OF JAPANESE		429	1	2	412	3	11
Fischel, 1906	White	524	2		499		23
Trotter, 1929	White	92	5		84		3
Frey, 1929	White	150	9	1	137	1	2
TOTAL OF WHITES		766	16	1	720	1	28
TOTAL OF ALL RACES		1356	25	3	1279	4	45

information on this condition in catarrhine monkeys exists only in regard to the macaque (genus *Pithecus*, see table 1). In this representative of the lower Old World primates the thoracic region has become reduced to only 12 vertebrae, less than 10 per cent of the cases still containing 13 segments. In other catarrhine monkeys 12 and 13 thoracic vertebrae seem also to be the only numbers to occur according to the records of Giebel (1877), Flower (1888), and Ranke (1897). Only the first of these authors lists in his tables one single specimen with 14 thoracic vertebrae. Among the higher primates the *Hylobatidae* and the gorilla and the chimpanzee have on an average 13 thoracic vertebrae, whereas the orang and man have only 12. In the gibbon, siamang, and chimpanzee, as shown clearly by table 1, 12 thoracic vertebrae occur more frequently than 14. In the comparatively few specimens with 14 thoracic vertebrae the last pair of ribs is as a rule very short, as might be expected from its atavistic nature. In one chimpanzee, however, even this fourteenth pair of ribs is still very long, the bony portion measuring 96 mm. on one side and 84 mm. on the other (Nat. M. 220062). The minimum number of thoracic

vertebrae of all primates is found in the orang-utan, which has an average of only 11.9 and reductions in this number more than twice as frequent as increases. The average for man is 12 in all the races listed in tables 1 and 2. Minus-variations in the number of thoracic vertebrae are more common than plus-variations in the negro but rarer in the Japanese and white.

Keith (1903) gives a table showing the average number of the last rib-bearing vertebra in higher primates. Even though his series are considerably smaller than those of the writer, his data correspond quite closely to those contained in table 1. By deducting the number of cervical vertebrae from the averages of Keith his figures can be compared directly with those of table 1. Average number of thoracic vertebrae according to Keith: 13.0 in 33 gibbons, 13.1 in 35 chimpanzees, 13.0 in 29 gorillas, and 12.0 in 31 orang-utans. The averages obtained by the writer are lower by 0.1 in all these primates, except the gorilla. According to Tredgold (1897) chimpanzees have on an average 13.2 pair of ribs, whereas gorillas have only 12.9. The existence of such a difference is not confirmed by the author's results, as both apes have an average of 13.0 thoracic vertebrae.

On the basis of the data discussed in this chapter, it seems highly probable that at least 14 and 15 thoracic vertebrae represent the primitive condition, whereas only 11 form a marked specialization. The latter has been found only in man and, much more frequently, in the orang-utan. It is interesting to note that the gibbon, the siamang, and the two large African apes have retained a greater number of thoracic vertebrae than have the macaque and other catarrhine monkeys. It is not at all inconceivable that the maximum numbers of thoracic vertebrae, 16 and 17, may be regarded as the consequence of a secondary increase in presacral segments or as the result of a transformation from lumbar vertebrae.

According to the figures in table 1 there exist marked differences between the various primates in regard to the degree of variability in the number of thoracic vertebrae. This relative stability is most clearly expressed by the maximum of the percentage frequencies of all the variations within the same series of primates. For instance, in the genus *Cebus* 14 thoracic vertebrae occur with the highest frequency, namely in 70 per cent of the cases; in the genus *Ateles*, on the other hand, this particular variation is present in 90 per cent of the specimens, only 10 per cent deviating from this condition. *Ateles*, therefore, is considerably more constant than *Cebus* in regard to the feature under

discussion. Of all the primates studied, man is the most stable form, since on an average over 94 per cent of the cases have one and the same number of thoracic vertebrae. Negroes show somewhat less constancy than Japanese and whites. The macaques and the spider monkeys are but little more variable than man. In all the other primates of table 1 deviations from the "type" are much more common than in man, occurring, for instance, in 28 per cent of all orang-utans in contrast to the 8.7 to 4.0 per cent in human races.

Lumbar Vertebrae

The number of lumbar vertebrae varies among all the primates between 3 and 9. The higher variations, from 6 to 9, occur in the prosimians, whereas the numbers 3 to 7 are found in the suborder of the *Simiae*. Eight and even 9 lumbar vertebrae are quite common in

TABLE 3

Percentage Distribution of Variations and Averages of the Number of Lumbar Vertebrae in Primates. The Data for Man Are Calculated from the Figures in Table 4

PRIMATE	TOTAL OF CASES	NUMBER OF LUMBAR VERTEBRAE							AVERAGE
		3	3½	4	4½	5	6	7	
Cebus	37			2.7		35.1	*56.8*	5.4	5.6
Alouatta	24					*91.7*	8.3		5.1
Ateles	20			*100.0*					4.0
Pithecus	50						16.0	*84.0*	6.8
Hylobates	57			8.8		*86.0*	5.2		5.0
Symphalang. syndactylus	16			37.5		*56.2*	6.3		4.7
Hylobatidae	75			14.7		*78.7*	6.6		4.9
Pongo pygmaeus	79	5.1	5.1	*78.5*	2.5	8.8			4.0
Pan	55	16.4	3.6	*74.5*		5.5			3.9
Gorilla gorilla	75	38.7		*60.0*		1.3			3.6
Gorilla beringei	7	*57.1*		42.9					3.4
Gorilla	82	40.3		*58.5*		1.2			3.6
Homo (Negroes)	160			7.5		*86.3*	6.2		5.0
Homo (Japanese)	148			2.7		*91.2*	6.1		5.0
Homo (Whites)	766			2.3	0.1	*93.3*	4.3		5.0
Homo sapiens	1074			3.2	0.1	*91.9*	4.8		5.0

TABLE 4

The Number of Lumbar Vertebrae in Different Human Races According to Various Reports in the Literature and Considering Also the Author's New Series of Negroes

AUTHOR	RACE	TOTAL OF CASES	NUMBER OF LUMBAR VERTEBRAE			
			4	4½	5	6
Trotter, 1929	Negro	97	8		80	9
Schultz	Negro	63	4		58	1
TOTAL OF NEGROES		160	12		138	10
Nishi, 1928	Japanese	148	4		135	9
Fischel, 1906	White	524	12		502	10
Trotter, 1929	White	92	3		77	12
Frey, 1929	White	150	3	1	135	11
TOTAL OF WHITES		766	18	1	714	33
TOTAL OF ALL RACES		1074	34	1	987	52

various prosimian genera but have never been found, as far as the author could ascertain, in any of the monkeys or apes, even though several forms have an *average* number of 7. There can be no doubt that extreme reductions in the number of lumbar vertebrae represent high specializations, but it seems doubtful whether the maximum number of these vertebrae can be regarded as the original condition or, rather, as an opposite specialization in which thoracic segments became transformed into lumbar ones. In such cases in which 9 lumbar vertebrae combine with 15 thoracic ones, or 8 lumbar with 16 thoracic ones, as reported for *Loris* by v. d. Hoeven, Blaineville, Rosenberg, and Ranke (quoted by the last author in 1897), the high number of lumbar segments is in all likelihood due to a specialized increase in the number of presacral vertebrae.

Among the *Simiae* there exists no evidence for an evolutionary trend to increase the number of lumbar vertebrae, except in the few instances in which a slight increase takes place, clearly at the expense of the number of thoracic vertebrae. The opposite tendency, *i. e.*, to reduce the number of lumbar vertebrae, is very evident from the figures in table 3. Among the platyrrhines *Cebus* still possesses 6 lumbar vertebrae in the majority of the cases, though 38 per cent of the

specimens have already a lesser number. In *Alouatta* the average has decreased to 5.1 and in the also closely allied *Ateles* to as few as 4. Among the higher primates 5 lumbar vertebrae form the rule for gibbons and man, whereas in the siamang, orang, chimpanzee, and gorilla this average has become reduced in the order stated. Even though the series is still far too small to be reliable, it is interesting to note that four out of seven mountain gorillas have only 3 lumbar vertebrae. Such an extreme shortening of the lumbar region of the spine must greatly diminish the flexibility of the trunk, since it brings the thorax into close proximity to the pelvis. Indeed, in most gorilla skeletons the last pair of ribs lies strikingly close to the iliac crests of the pelvis.

The various groups of primates listed in table 3 differ widely in regard to the degree of variability in the number of lumbar vertebrae. In *Ateles* this number is constant in all specimens examined, and in *Alouatta* and in man 92 per cent of the cases have one and the same number. In *Cebus*, *Symphalangus*, and *Gorilla*, on the other hand, less than 6 out of every 10 specimens possess the same number of lumbar vertebrae. Man is more stable than all the other higher primates in regard to the number of lumbar vertebrae, as he was found to be in regard to the thoracic vertebrae. There can be no doubt that the distribution of variations in some of the primate series clearly shows the direction of the evolutionary change. In the genus *Gorilla*, *e. g.*, minus-variations occur in 40 per cent of the cases, whereas plus-variations occur in only 1 per cent. This demonstrates with practical certainty the tendency to reduce the lumbar vertebrae from 4 to 3.

A comparison between tables 1 and 3 shows that the lumbar vertebrae are more variable than the thoracic ones in *Cebus*, *Pithecus*, *Gorilla*, and all the human races. The two types of vertebrae are equally variable in *Hylobatidae* and in *Pan*, and the lumbar ones are more constant then the thoracic ones in *Alouatta*, *Ateles*, and *Pongo*.

Thoracolumbar Vertebrae

The combined number of thoracic and of lumbar vertebrae varies extensively among the primates, namely between 15 and 24. For the prosimians the extremes found in the literature are 18 and 24, the latter having been recorded more frequently than the former. The number of thoracolumbar vertebrae in platyrrhines ranges between 17 and 22, the maximum being restricted to *Aotus* (Flower, 1884; Ranke, 1897; v. d. Broek, 1908) and the minimum to *Ateles* (see table

5). In catarrhines this range extends from 15 to 19, not a single specimen having been recorded with 20 segments, although several catarrhine monkeys have an *average* number of 19 vertebrae. Todd (1922) reached the conclusion that in all likelihood the number of thoracolumbar vertebrae in the ancestral stem of primates was 19. The writer is for various reasons inclined to accept 20 as the original and most primitive number of these vertebrae in primates. According to Gregory (1910) both these figures are equally common among the different mammalian orders. Thus, we have to assume that in many prosimian genera, as also in a variety of other mammalian groups, there prevails a tendency toward increase in the number of thoracolumbar vertebrae. Among a few platyrrhines and many catarrhines, on the other hand, there exists unquestionably an evolutionary trend to reduce the number of these vertebrae, which is equivalent to a migration of the sacrum and pelvis in a cephalic direction. The extreme reduction among platyrrhines has been reached by *Ateles* with an average number of those vertebrae of only 17.9 in contrast to the average of 19.5 in the closely allied genus *Cebus*. Since both these genera have the same number of thoracic vertebrae, the process of reduction affected in this case exclusively the lumbar region (see tables 1 and 3). In the family *Hylobatidae* the thoracolumbar portion of the spine has become more reduced in *Symphalangus syndactylus* than in the genus *Hylobates*. In the former more than 44 per cent of the specimens have only 17 of these vertebrae; in the latter this percentage amounts merely to 17.5. Again it is found that the lumbar and not the thoracic region of the spine produced this difference in the number of segments. Among the highest primates man and orang-utan possess the same number of thoracic vertebrae but in the former there are still 5 lumbar vertebrae, in the latter only 4. The orang-utan has the smallest number of thoracolumbar vertebrae among all primates and in 14.5 per cent of the orangs examined there are even as few as 15 of these vertebrae, a number never found in man and but rarely in the African apes (see table 5). That all of the seven mountain gorillas have only 16 thoracolumbar vertebrae, producing a much lower average than in the West-African gorilla, is certainly significant and renders it particularly desirable that more specimens of the rare *Gorilla beringei* should be investigated.

Table 5 shows clearly that on an average all three large apes have fewer thoracolumbar vertebrae than man. The latter, therefore, is in this respect less specialized and more conservative than are the

TABLE 5

Percentage Distribution of Variations and Averages of the Number of Thoracolumbar Vertebrae in Primates. The Data for Man Are Calculated from the Figures in Table 6

PRIMATE	TOTAL OF CASES	NUMBER OF THORACOLUMBAR VERTEBRAE							AVERAGE
		15	16	17	18	19	20	21	
Cebus	38				2.6	*47.4*	*47.4*	2.6	19.5
Alouatta	25				12.0	*68.0*	20.0		19.1
Ateles	22			13.6	*86.4*				17.9
Pithecus	53				7.5	*92.5*			18.9
Hylobates	63			17.5	*76.2*	6.3			17.9
Symphalang. syndactylus	18			44.4	*55.6*				17.6
Hylobatidae	83			22.9	*71.1*	6.0			17.8
Homo (Negroes)	347		4.0	*90.5*	5.5				17.0
Homo (Japanese)	329		2.7	*90.6*	6.7				17.0
Homo (Whites)	3180		2.8	*92.3*	4.9				17.0
Homo sapiens	3856		2.9	*92.0*	5.1				17.0
Pan	63	1.6	19.0	*74.6*	4.8				16.8
Gorilla gorilla	79	1.3	34.2	*63.2*	1.3				16.6
Gorilla beringei	7		*100.0*						16.0
Gorilla	86	1.2	39.5	*58.1*	1.2				16.6
Pongo pygmaeus	83	14.5	*75.9*	9.6					16.0

former. It may be mentioned here that the averages for the anthropoid apes in table 5 are smaller by only 0.1 than the corresponding averages obtained by Keith (1903) from less extensive series.

The differences between various primates in regard to the degree of stability of the number of thoracolumbar vertebrae are best seen on the diagrams in figure 1. Man and *Pithecus* have the highest black columns on account of the fact that they alone have one and the same number of these vertebrae in over 90 out of every 100 individuals. *Cebus, Symphalangus,* and *Gorilla* are the least stable forms, since in these groups less than 60 per cent of the cases adhere to the typical condition. This is indeed a striking difference, according to which man is infinitely more stable than the other higher primates, a fact

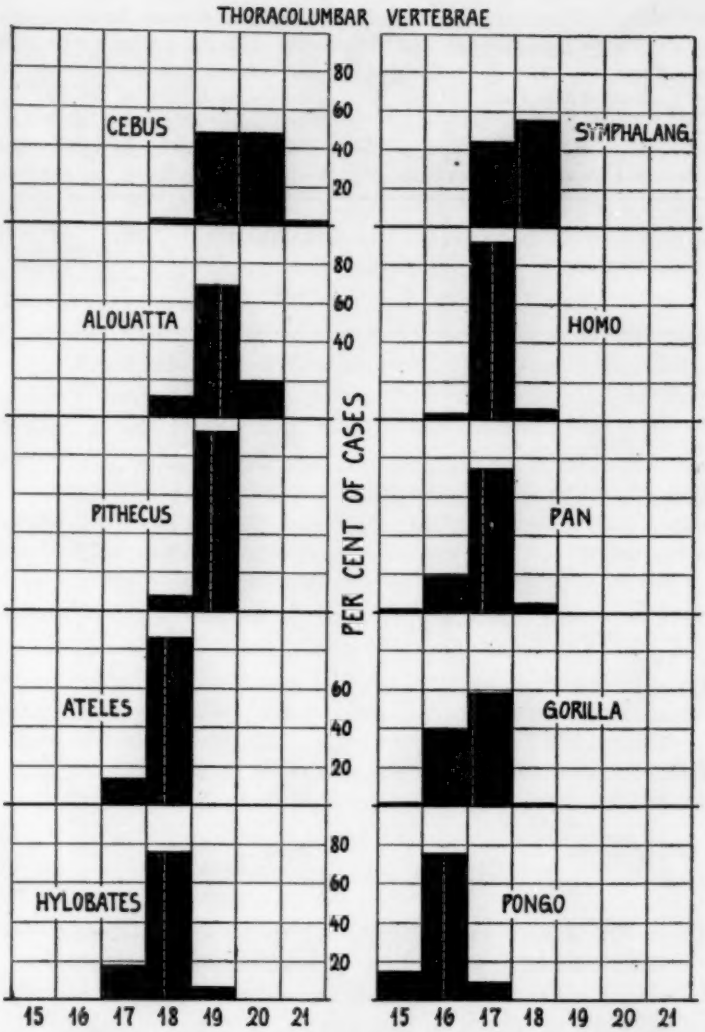


FIG. 1. THE PERCENTAGE DISTRIBUTION OF VARIATIONS IN THE NUMBER OF THORACOLUMBAR VERTEBRAE IN DIFFERENT PRIMATES, CONSTRUCTED FROM THE DATA IN TABLE 5. In this and the following similar figure the perpendicular, white, broken lines represent the position of the average number of vertebrae. The diagram for *Symphalangus* refers to *S. syndactylus* only and not to *S. klossi*.

TABLE 6

The Number of Thoracolumbar Vertebrae in Different Human Races According to Various Reports in the Literature and Considering Also the Author's New Series of Negroes. From the Latter Were Omitted All Specimens from the Western Reserve University, Since These Had Already Been Used in the Report of Willis. Willis' Report Was Condensed for the Purpose of This Table. Bardeen's Large Series of Whites Contained a Few Negroes Who Could Not Have Materially Altered the Frequency and Distribution of Variations.

AUTHOR	RACE	TOTAL OF CASES	NUMBER OF THORACOLUMBAR VERTEBRAE		
			16	17	18
Willis, 1923	Negro	218	3	206	9
Trotter, 1929	Negro	97	10	79	8
Schultz	Negro	32	1	29	2
TOTAL OF NEGROES		347	14	314	19
Hasebe, 1913	Japanese	181	5	163	13
Nishi, 1928	Japanese	148	4	135	9
TOTAL OF JAPANESE		329	9	298	22
Rabl (Fischel)	White	640	8	607	25
Bardeen a. o., 1904	White	1059	45	967	47
Adolphi, 1905	White	83	2	77	4
Fischel, 1906	White	524	14	477	33
Willis, 1923	White	632	6	602	24
Trotter, 1929	White	92	8	69	15
Frey, 1929	White	150	7	135	8
TOTAL OF WHITES		3180	90	2934	156
TOTAL OF ALL RACES		3856	113	3546	197

already shown, though based upon very much less extensive data, by Todd (1922). Todd's (1924) later generalization, to the effect that man's stability appears to be unique among primates, can no longer be maintained even in regard to thoracolumbar vertebrae alone, since it is now known that at least the macaque is no more variable than man.

It at first seems that part of the differences in the degrees of variability may be accounted for by the fact that some of the groups of primates compared represent genera containing several species, and others only a single species. The species *Gorilla gorilla*, however, has 17 thoracolumbar vertebrae in only 63 per cent of the cases, whereas

the genus *Pan*, containing many species, has the same number in 75 per cent of the specimens. Similarly, the species *Symphalangus syndactylus* is much more variable than the entire genus *Hylobates*. An analysis of the tables I to X shows furthermore that in most cases the distribution of variations is very similar in different species of the same genus. Between the different human races there exist some slight differences in degree of constancy, namely 1.8 between negroes and whites and 1.7 between Japanese and whites. However, the probable error of the first difference amounts to $\pm$ 1.0 and that of the second difference to $\pm$ 1.1, which implies that these differences are not significant.

As readily shown by table 5 and by figure 1, in all the unstable higher primates variations amounting to a reduction in thoracolumbar vertebrae are much more common than variations in the opposite direction. In the gorilla, *e. g.*, the former amount to 40.7 per cent of the cases, the latter to only 1.2. In the relatively constant man, on the other hand, plus-variations are actually more frequent than minus-variations. The difference, however, is almost negligible if compared with the differences between these variations in other higher primates. This finding supports the claim that in gibbons and anthropoid apes the reduction in the number of thoracolumbar vertebrae is still actively progressing to-day, whereas in man this evolutionary process has come to a standstill. For instance, the distribution of variations in chimpanzee, as shown by the diagram for *Pan* in figure 1, could change to that in gorilla by a mere doubling in frequency of the variation of 16 thoracolumbar vertebrae. This would reduce the average number of vertebrae from 16.8, as now in chimpanzee, to 16.6 as already reached by the gorilla. It is sufficient to mention in this connection that Frets (1909) has shown by means of animal breeding that numerical variations of vertebrae are hereditary.

Sacral Vertebrae

The number of vertebrae, fusing more or less into one rigid structure—the sacrum—varies among the lower primates usually between 2 and 4,[2] among the *Hylobatidae* between 3 and 6, and among the

[2] Ranke (1897) lists two specimens of *Loris tardigradus* with 6 sacral vertebrae. These two cases, however, represent exceptions for this particular species as well as among all other prosimians (see *e. g.* the extensive tables by Giebel, 1877; Flower, 1888; and by Ranke himself). A few isolated prosimian genera seem to have acquired independently the tendency to fuse 4, or even more, vertebrae into the sacrum.

highest primates between 4 and 7. These figures alone demonstrate that with the general advance of primate evolution more and more vertebrae tend to solidify into the sacrum. Two as well as 4 sacral vertebrae are very rare among the lower primates, whereas 3 and 6 are rare in gibbons, and 4 and 7 exceptional among the large apes and man. As shown by table 7, this progressive sacralization of vertebrae has reached a greater extreme in chimpanzee and gorilla than in man.

The average numbers of sacral vertebrae in higher primates obtained by Keith (1903) are below the averages obtained by the writer. The following values are from Keith: gibbon, 4.3; orang-utan, 4.7; gorilla, 5.1; and chimpanzee, 5.2. The greatest difference between these averages and the corresponding ones in table 7 exists in the series of orang-utans and of gorillas. Of the former Keith had 37 specimens,

TABLE 7

Percentage Distribution of Variations and Averages of the Number of Sacral Vertebrae in Primates. The Data for Man Are Calculated from the Figures in Table 8

PRIMATE	TOTAL OF CASES	NUMBER OF SACRAL VERTEBRAE						AVERAGE
		2	3	4	5	6	7	
Cebus	37	2.7	*97.3*					3.0
Alouatta	24		*91.7*	8.3				3.1
Ateles	20		*95.0*	5.0				3.1
Pithecus	50		*100.0*					3.0
Hylobates	54			*59.3*	40.7			4.4
Symphalang. syndactylus	16		6.2	*56.4*	31.2	6.2		4.4
Hylobatidae	72		1.4	*58.3*	38.9	1.4		4.4
Pongo pygmaeus	88			11.4	*68.4*	20.2		5.1
Homo (Negroes)	155				*89.0*	11.0		5.1
Homo (Whites)	631			1.0	*76.9*	21.9	0.2	5.2
Homo (Japanese)	181			1.1	*70.2*	28.7		5.3
Homo sapiens	967			0.8	*77.7*	21.4	0.1	5.2
Pan	42			4.8	*47.6*	*47.6*		5.4
Gorilla gorilla	54				*50.0*	48.2	1.8	5.5
Gorilla beringei	7				28.6	*71.4*		5.7
Gorilla	61				47.5	*50.9*	1.6	5.5

TABLE 8

The Number of Sacral Vertebrae in Different Human Races According to Various Reports in the Literature and Considering Also the Author's New Series of Negroes

AUTHOR	RACE	TOTAL OF CASES	NUMBER OF SACRAL VERTEBRAE			
			4	5	6	7
Trotter, 1929	Negro	97		90	7	
Schultz	Negro	58		48	10	
TOTAL OF NEGROES		155		138	17	
Paterson, 1896	White	100	3	62	34	1
Adolphi, 1912	White	289	2	225	62	
Trotter, 1929	White	92		82	10	
Frey, 1929	White	150	1	117	32	
TOTAL OF WHITES		631	6	486	138	1
Hasebe, 1913	Japanese	181	2	127	52	
TOTAL OF ALL RACES		967	8	751	207	1

the author 88; of the latter 24 cases were observed by Keith, 61 by the author. Naturally, these differences in size between the series used explain, at least in part, the discrepancies in the averages.

According to the tables 7 and 8 the different human races seem to have on an average slightly different numbers of sacral vertebrae. It is also noteworthy that the negroes with the lowest average are far more constant in this respect than the Japanese with the highest average. Six sacral vertebrae occur nearly three times more frequently in Japanese than in negroes. It will be interesting to see whether future additional observations will place this racial difference on a firmer basis.

The above-mentioned evolutionary trend, according to which more and more vertebrae participate in the formation of the sacrum, is clearly evident even within single groups of primates. In the *Hylobatidae, e. g.*, the number of sacral vertebrae occurring with greatest frequency is four and, therefore, represents the typical condition, but 5 and 6 vertebrae are already present in 40.3 per cent of the cases, whereas variations of 3 vertebrae have been observed in only 1.4 per cent of all gibbons.[3] Similarly, among nearly a thousand human sacra

[3] Wood Jones (1929) states that *Hylobatidae* have three sacral vertebrae, but does not mention how many of these rare cases he has seen.

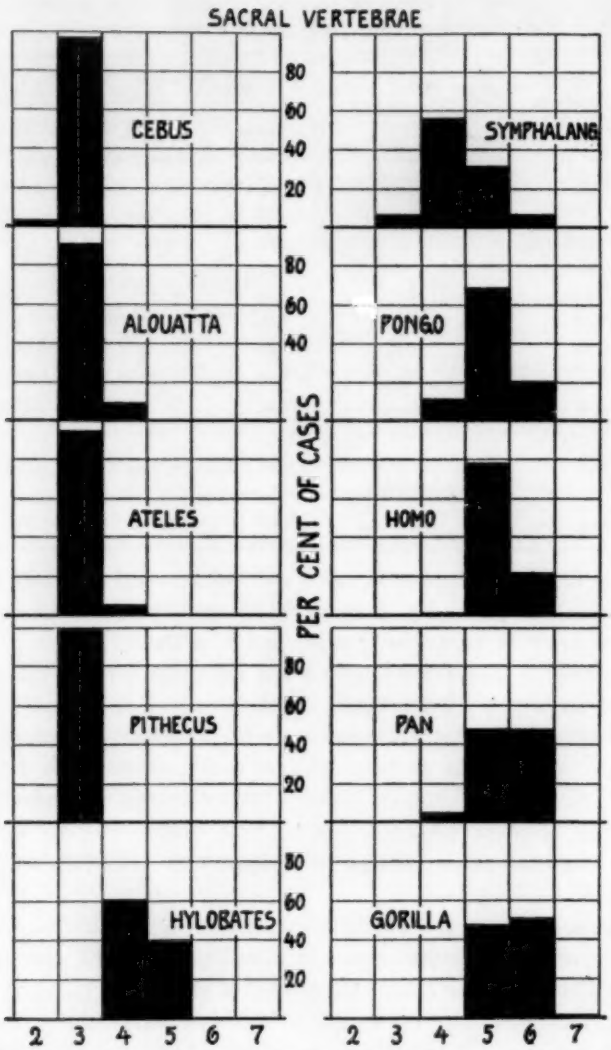


FIG. 2. THE PERCENTAGE DISTRIBUTION OF VARIATIONS IN THE NUMBER OF SACRAL VERTEBRAE IN DIFFERENT PRIMATES, CONSTRUCTED FROM THE DATA IN TABLE 7.

minus-variations amount to less than 1 per cent but plus-variations to 21.5 per cent. In *Gorilla gorilla* the combined progressive variations have become as frequent as the cases with 5 sacral vertebrae, whereas the retarded variations of only 4 vertebrae have disappeared altogether.

Figure 2 shows at a glance the remarkable constancy of the number of sacral vertebrae in the lower primates, which contrasts sharply with the lack of stability in this feature among the higher primates. Among the latter man is the least variable form, just as he was found to be more stable than gibbons and large apes in regard to all the other types of vertebrae discussed in previous chapters. In comparing table 7 with table 5 it is found that the number of sacral vertebrae is much more constant than that of the thoracolumbar ones in the lower primates, but a great deal more variable in all the higher primates, including man.

Certain dimensions and proportions of the primate sacrum will be discussed in the chapter on the pelvis.

Coccygeal Vertebrae

The maximum number of caudal vertebrae in primates is 34 (in a specimen of *Ateles* according to Giebel, 1877), the minimum is 1, and has been found repeatedly in gibbons, siamangs, and orang-utans (see table 9). This represents a tremendous total range of variations. Among the higher primates, which all lack an outer tail, the coccygeal vertebrae vary only between 1 and 6, the maximum occurring much more rarely than the minimum. It is interesting to find that the evolutionary reduction in the number of tail vertebrae has progressed least among all higher primates in man (average 4.2) and most in *Hylobates* (average 2.6). It might be assumed that this difference could be explained by the fact that the pelvis and sacrum have migrated farther in a cephalic direction in man (24 presacral vertebrae) than in the gibbons (25 presacral vertebrae), thus having liberated in the former the last sacral vertebra which might have degenerated into an additional coccygeal vertebra. Such a hypothesis, however, can hardly be maintained in view of the fact that the number of precaudal vertebrae is the same in gibbon and man and that the total number of all vertebrae in the former is less than in the latter (see table 11). In the author's opinion the data in table 9 prove decisively that the coccygeal region of man has remained less specialized than that of the large apes and gibbons. In this connection it might be recalled, that in regard to the number of sacral vertebrae man was found to be less

advanced than the two African apes and in regard to the thoracolumbar vertebrae more primitive than all the anthropoids.

TABLE 9

Percentage Distribution of Variations and Averages of the Number of Coccygeal Vertebrae in Primates. The Data for Man Are Calculated from the Figures in Table 10

PRIMATE	TOTAL OF CASES	NUMBER OF COCCYGEAL VERTEBRAE						AVERAGE
		1	2	3	4	5	6	
Homo sapiens	745			11.9	*61.1*	27.0		4.2
Pan	28		25.0	*35.7*	28.6	7.1	3.6	3.3
Gorilla gorilla	29		24.1	*44.9*	24.1	6.9		3.1
Gorilla beringei	4		25.0	*50.0*	25.0			3.0
Gorilla	33		24.3	*45.3*	24.3	6.1		3.1
Pongo pygmaeus	61	3.3	27.9	*54.0*	11.5	3.3		2.8
Symphalang. syndactylus	9	11.1	22.2	*44.5*	22.2			2.8
Hylobates	46	10.9	*37.0*	32.6	15.2	4.3		2.6
Hylobatidae	57	10.5	*33.3*	*33.3*	15.8	7.1		2.7

TABLE 10

The Number of Coccygeal Vertebrae in Man According to Various Reports in the Literature and Considering Also the Author's Small Series of Negroes

AUTHOR	REMARKS	TOTAL OF CASES	NUMBER OF COCCYGEAL VERTEBRAE		
			3	4	5
Bianchi	quoted by Le Double	19	2	12	5
Calori	" " "	50	5	38	7
Dwight	" " "	35	6	21	8
Havelock	" " "	31	5	23	3
Marino	" " "	54	0	17	37
Staderini	" " "	100	17	60	23
Le Double, 1912	p. 360 & p. 362	242	23	164	55
Paterson, 1896		100	17	60	23
Hasebe, 1913	Japanese	95	8	52	35
Schultz	Negroes	19	6	8	5
TOTAL		745	89	455	201

The average numbers of coccygeal vertebrae obtained by Keith (1903) are higher than those of the author: namely, 3.7 for gibbon and chimpanzee, 3.3 for gorilla, and 3.1 for orang-utan. Since all the averages for sacral vertebrae are lower in the table of Keith than in that of the author it seems that Keith may have inclined to interpret last sacral vertebrae as first coccygeal ones.

The coccygeal vertebrae tend to vary individually very much more than any of the other vertebrae; but, like all the other vertebrae, they are more constant in man than in gibbons and anthropoid apes. In the *Hylobatidae* the highest percentage frequency of any particular variation is only 33, in the chimpanzee only 36, but in man it amounts to 61.

This enormous variability in the number of coccygeal vertebrae is most likely connected with the fact that ontogenetically this number is not constant. The human embryo, *e. g.*, possesses anywhere from 7 to 9 vertebral rudiments in the tail (Kunitomo, 1918); of these a varying but always considerable number disappears in the course of fetal growth. In this respect the coccygeal portion of the spine behaves differently from the other regions, since not all of the variations in the former have to be congenital as some may be of a developmental nature.

The Number of Vertebrae in General

According to table 11 man has the greatest total number of vertebrae among the higher primates, whereas in orang-utan this number has become most reduced. This agrees completely with the findings of Keith (1903). For gibbon, chimpanzee, and gorilla, however, this author obtained on an average one more vertebra than did the writer, but in spite of this these apes fall between the above-mentioned extremes.

It will be noted that the averages in table 11 for the genus *Hylobates* and for the species *Symphalangus syndactylus* are below the average for the entire family *Hylobatidae*. The reason for this discrepancy lies in the fact that the last average includes also the two specimens of *Symphalangus klossi* (see table VI), which had 35 vertebrae each. Such a high total was found only in two of the gibbons and in none of the large siamangs. For this reason and particularly for certain others, to be discussed in later chapters, the author inclines to the view that *Symphalangus klossi* may not properly belong to the same genus as *S. syndactylus*.

The variability of the total number of vertebrae is very great in the higher primates. As in the previous chapters, man is again found to be less variable than the gibbons and large apes. The highest percentage frequency of any particular variation amounts to only 29.4 in *Gorilla*, to 35.2 in the *Hylobatidae*, to 44.1 in *Pan*, and to 50.0 in *Pongo*, whereas it rises to 72.2 – 85.5 in man.

TABLE 11

Percentage Distribution of Variations and Averages of the Number of Vertebrae in the Entire Spinal Column of Primates

PRIMATE	TOTAL OF CASES	TOTAL NUMBER OF VERTEBRAE								AVERAGE
		29	30	31	32	33	34	35	36	
Homo (Paterson)	36				5.5	*72.2*	20.0	2.7		33.3
Homo (Bardeen)	104				5.8	*85.5*	8.5			33.0
Pan	34			8.8	*44.1*	26.5	17.7		2.9	32.6
Gorilla gorilla	30		3.3	30.0	20.0	*33.3*	6.7	6.7		32.3
Gorilla beringei	4			25.0	*75.0*					31.7
Gorilla	34		2.9	*29.4*	26.5	*29.4*	5.9	5.9		32.2
Hylobates	46		6.5	*37.0*	28.3	15.2	8.7	4.3		31.9
Symphalang. syndactylus	9		11.1	33.3	*44.5*	11.1				31.6
Hylobatidae	57		7.0	*35.2*	29.8	14.0	7.0	7.0		32.0
Pongo pygmaeus	58	6.9	24.1	*50.0*	17.2	1.8				30.8

Since each region of the spine varies in regard to the number of its vertebrae, it is of interest to learn the degree of constancy in the combination of such variations. For instance, man has as a rule 12 thoracic, 5 lumbar, and 5 sacral vertebrae. This represents the most frequent combination of regional variations, *i. e.*, it is the statistical norm for the human precaudal spine. According to table 12 this norm is present in less than 3 out of every 4 individuals, namely on an average in only 71.2 per cent of the cases. Only one of the various primates examined is more constant in this respect than man; this is the macaque in which the statistical norm is found in 84 per cent of the specimens. In the remaining groups of primates these percentage frequencies are very low, ranging from 46.0 to only 29.3 in the gorilla. In view of the fact that, for instance, less than one out of every three gorilla spines shows the same combination of variations in only three

TABLE 12

Percentage Frequency of Statistical Norm of Precaudal Vertebrae in Primates

PRIMATE	TOTAL OF CASES	STATISTICAL NORM:			PERCENTAGE OF CASES WITH NORM
		Thoracic	Lumbar	Sacral	
Cebus	37	14	6	3	*40.6*
Pithecus	50	12	7	3	*84.0*
Hylobatidae	73	13	5	4	*41.1*
Pongo pygmaeus	76	12	4	5	*46.0*
Pan	40	13	4	5	*35.0*
Gorilla	58	13	4	5	*29.3*
Homo (Rosenberg, 1912)	100	12	5	5	68.0
Homo (Trotter, 1929)	189	12	5	5	73.5
Homo (Frey, 1929)	150	12	5	5	68.5
Homo (Schultz)	54	12	5	5	75.9
Homo sapiens (Total)	493	12	5	5	*71.2*

of the spinal regions, this "norm" is merely a mathematical one. The biological norm of gorilla is really represented by several different combinations of variations which have not yet reached a compromise in a single new type.

From these discussions of the number of vertebrae in the different spinal regions of primates the following general conclusions can be drawn. In several respects the human spine has remained less specialized and more original than that of the anthropoid apes. The latter as well as the gibbons are very much more variable than man, but man is equally or more variable than some of the lower primates. In all the higher primates the numbers of the sacral and especially of the coccygeal vertebrae are less stable than those of the thoracic and the lumbar vertebrae. It can be stated, therefore, that each structure, or group of structures, of each type of primate has its own characteristic tendency to vary. For this reason one must bear in mind that any comparison between different animals in regard to their variability must always be limited to definite features. For instance, in regard to the number of thoracolumbar vertebrae *Alouatta* was found to be much more variable than *Ateles* (table 5) but, as shown in a former paper by the author (1926), all the cranial features are more variable in the latter than in the former.

STERNUM

All the prosimians, platyrrhines, and lower catarrhines possess long and slender *sterna*, whereas all the higher primates have relatively

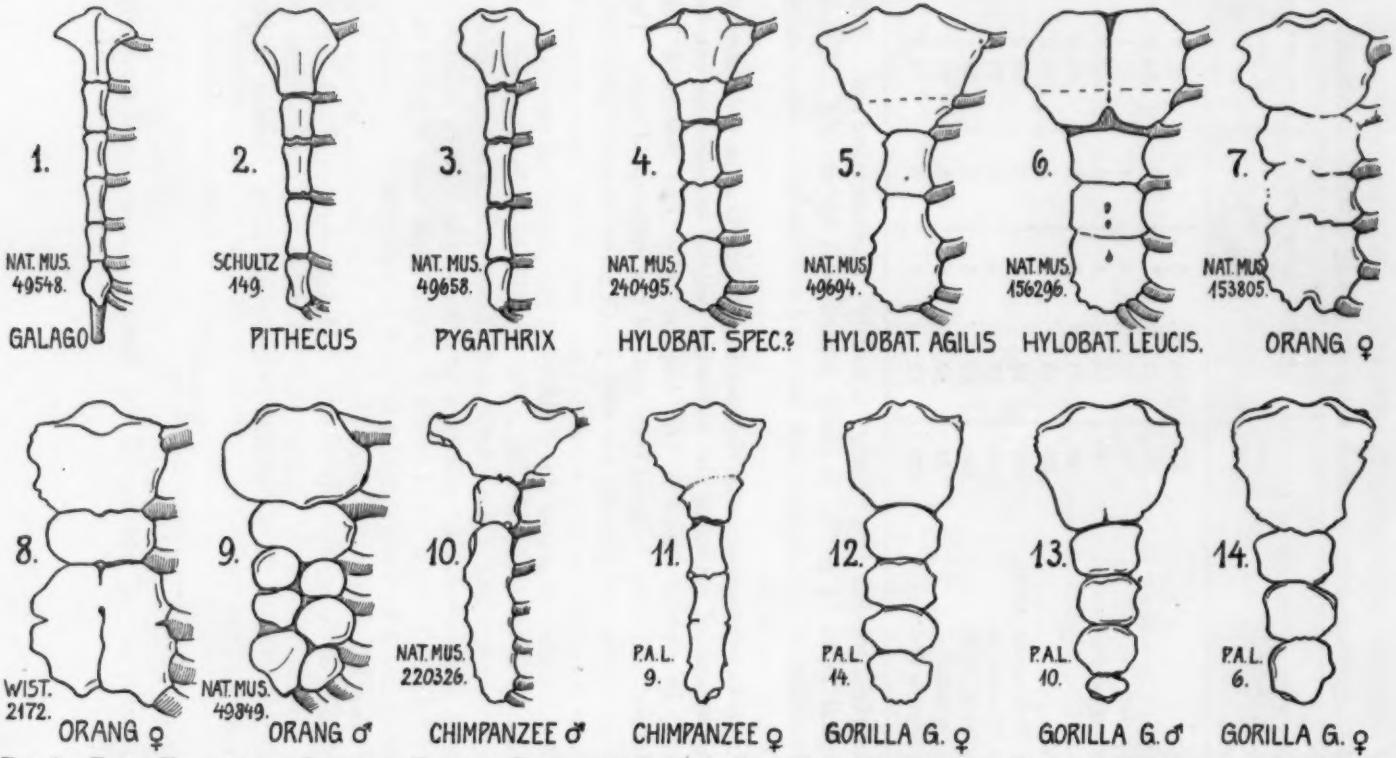


FIG. 3. FRONT VIEWS OF THE STERNA OF PRIMATES REDUCED TO THE SAME LENGTH OF MANUBRIUM + CORPUS STERNI (DRAWN WITH DIOPTROGRAPH). This series is continued in figure 4.

GRAPH). This series is continued in figure 4.

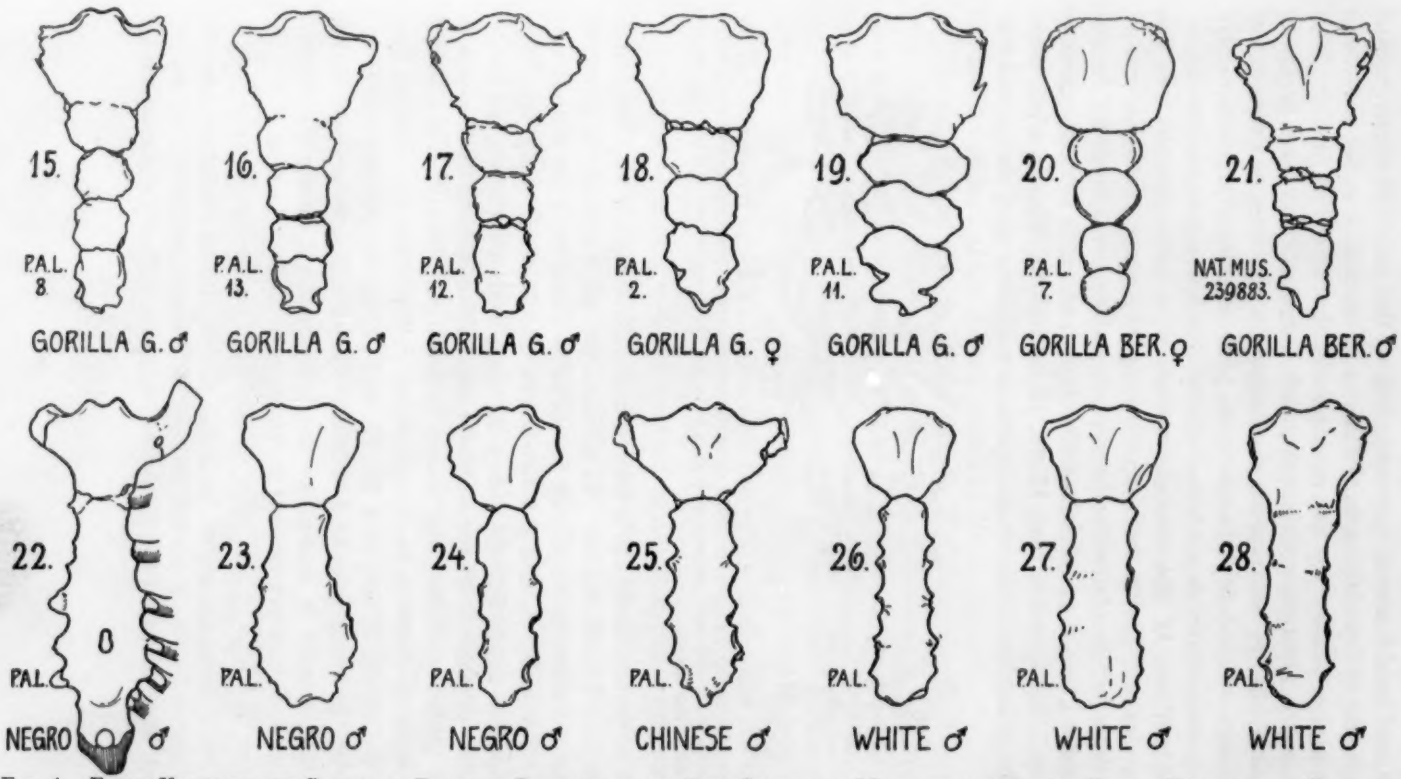


FIG. 4. FRONT VIEWS OF THE STERNA OF PRIMATES REDUCED TO THE SAME LENGTH OF MANUBRIUM + CORPUS STERNI (DRAWN WITH DIOPTROGRAPH). This series is continued from figure 3.

short and broad *sterna*, corresponding to the shape of their thorax. The degree of broadening in the *sterna* of the latter varies very considerably, as shown by the examples in the figures 3 and 4. The sternum of chimpanzees is not much broader than that of lower primates but, in contrast to the latter, in the former there exists a pronounced tendency toward fusion between several or, more rarely, all segments of the *corpus sterni*. In all the lower primates the intercostal portions of the sternum remain as a rule separate. In the orang-utan and gorilla this is true also in the majority of cases, except that the separation between the most caudal segments tends to become obliterated (see, *e. g.*, fusion between fourth and fifth sternal segments in No. 7, fig. 3, and in Nos. 17, 18, 19, and 21, fig. 4). In adult man, on the other hand, the *corpus sterni* is with very rare exceptions one

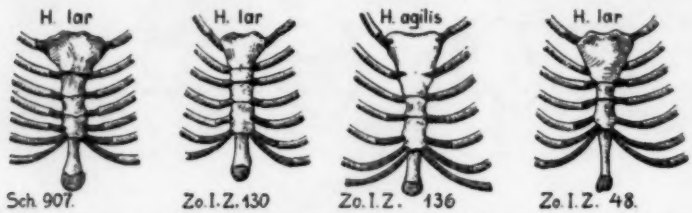


FIG. 5. SKETCHES OF THE STERNA OF FOUR FULLY ADULT HYLOBATES. In the *sternum* on the left the *manubrium* is entirely separate from the *corpus;* the three other variations show different degrees of fusion between the *manubrium* and the uppermost segment of the *corpus*.

single piece, and in old age it may occasionally even fuse with the manubrium (see No. 28, fig. 4). In gibbons the most cephalic segment of the *corpus sterni* is frequently found to be fused with the *manubrium* (Nos. 5 & 6, fig. 3, and the two *sterna* on the right of fig. 5). The examples in figure 5 show widely differing variations in regard to the presence or absence of the border between *manubrium* and *corpus* in adult gibbons. The same fusion between the *manubrium* and the first segment of the *corpus* can occur in chimpanzees and gorillas (see, *e. g.*, No 11, fig. 3, and Nos. 15, 16, and 21, fig. 4), but has never been observed in orang-utan and in man. These differences between the various primates in regard to the bony union between the sternal segments are not yet present in younger animals. In man, *e. g.*, the different portions of the body of the sternum do not become united until after puberty; before that age all the sternal segments are still separate as in young as well as adults of lower primates. It can be stated, therefore, that the primitive condition of 5 or 6 separate sternal

bones (not considering the xyphoid process) is found in all infantile primates. This number is retained throughout life by the prosimians and monkeys, but it is reduced in the course of growth in the higher primates. Among the latter this reduction is least pronounced in orang-utan and gorilla and has gone to the greatest extreme in man, who possesses only two sternal portions in adult life.

Indications of a midsagittal separation of the sternum are occasionally seen in man in the form of sternal foramina (*e. g.*, No. 22, fig. 4). Such a lack of ontogenetic fusion in the midline was never observed in any of the gorillas and chimpanzees studied by the author, but was quite common in orang-utan (*e. g.*, Nos. 8 & 9, fig. 3). In all these cases the midsagittal foramina or clefts were present in the *corpus sterni* only. A midsagittal separation of the *manubrium* was found in the single instance of the gibbon shown in No. 6, figure 3.

The sternum of a fully grown gibbon of an undetermined species from French Indo-China (No. 4, fig. 3) is particularly noteworthy since it differs rather markedly from all the other gibbon *sterna*. It is quite similar to the sternum of lower catarrhines, inasmuch as it is not only rather slender but also has retained all its separate segments, and there are still 8 pairs of sternal ribs attached to it, instead of only 7, as in the great majority of gibbons. It is interesting that these primitive conditions can persist in an individual of a genus characterized by broad *sterna* with many of the segments fused.

The maximum length of the sternum (without xyphoid process) in adult males of the four largest primates amounts to 137 mm. in orang-utans, 157 mm. in chimpanzees, 196 mm. in man,[4] and 221 mm. in gorillas (see table XI). In percentage of the anterior trunk height this sternum length varies in man according to Frey (1918) between 25 and 50. As shown by the data in table 13, this proportion amounts to 31 in a female chimpanzee, *i. e.*, to as much as in human females (average 30). In gorillas the individual variations range from 24.6 to 38.3, both extreme cases being males. The average for gorilla is 31.4 and, therefore, somewhat below the average for human males. The gibbon has the proportionately shortest sternum of all the primates in table 13.

[4] This maximum for man was obtained on the sternum of an adult male American negro, shown in No. 22, figure 4. The total length of this sternum, including the xyphoid process, measures 238 mm. and lies above the human range of variations in this dimension, as given by Martin (1928), who records as maximum 230 mm.

TABLE 13

The Length of the Sternum (without Xyphoid Process) in Per Cent of the Anterior Trunk Height (Suprasternal Notch to Upper End of Symphysis Pubis) in Some Primates. In the Gibbon the Trunk Height Was Measured on the Outer Body, in the Chimpanzee and in the Gorillas on the Ligamentous Skeletons before Their Maceration. The Minimum and Maximum Values for Man Are Given in Parentheses

PRIMATE	TRUNK HEIGHT	STERNUM LENGTH	$\frac{\text{STERNUM LENGTH}}{\text{TRUNK HEIGHT}} \times 100$
Hylobates lar ♂ ad. Sch. 907	254	57	*22.4*
Pan. spec.? ♀ ad. P. A. L. 9	384	119	*31.0*
Gorilla gorilla ♂ juv. P. A. L. 10	512	126	*24.6*
Gorilla bering. ♀ juv. P. A. L. 7	523	141	*27.0*
Gorilla gorilla ♂ ad. P. A. L. 11	539	162	*30.1*
Gorilla gorilla ♂ ad. P. A. L. 13	559	214	*38.3*
Gorilla gorilla ♂ ad. P. A. L. 12	570	212	*37.2*
Homo (Whites) ♂ (Frey, 1918)			*35* (27–50)
Homo (Whites) ♀ (Frey, 1918)			*30* (25–45)

By measuring the midsagittal length and the greatest breadth of the *manubrium* and of the *corpus sterni* data were obtained for calculating the following three proportions: Length of *manubrium* in percent-

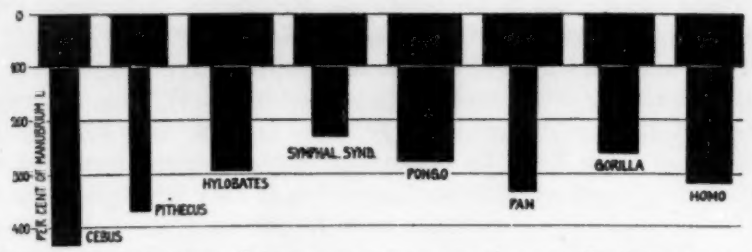


FIG. 6. DIAGRAMMATIC REPRESENTATION OF THE AVERAGE PROPORTIONS OF THE STERNA OF PRIMATES CONSTRUCTED FROM THE DATA IN TABLE 14. All reduced to the same length of the *manubrium*.

age of length of *corpus;* breadth of *manubruim* in percentage of length of *manubrium;* breadth of *corpus* in percentage of length of *corpus*. The individual values of these three indices are listed in table XI and the averages in table 14. The differences between these averages are illustrated diagrammatically in figure 6.

The length of the *manubrium* in relation to the length of the *corpus* varies among lower primates between 27 and 38, but among the higher ones between 43 and 82 (averages). This demonstrates that in the

TABLE 14

Average Proportions of the Sternum in Primates. The Detailed Data, from Which These Averages Have Been Calculated, Are Listed in Table XI

PRIMATE	SPECIMENS	MANUBR. L. / CORPUS L.	MANUBR. BR. / MANUBR. L.	CORPUS BR. / CORPUS L.
Galago	1	38.4	86.3	14.4
Cebus	1	29.8	94.2	15.8
Ateles	1	26.9	164.2	17.3
Pithecus	1	36.7	104.5	13.3
Pygathrix	1	36.4	105.0	14.5
Hylobates (several species)	12	51.9	154.4	38.7
Symphalangus klossi	2	60.1	149.6	44.1
Symphalangus syndactylus	3	82.4	135.3	53.2
Pongo pygmaeus	34	56.2	136.4	57.5
Pan (several species)	5	42.7	148.7	21.4
Gorilla gor. & beringei	18	61.6	129.5	44.8
Homo (several races)	7	46.2	125.7	38.2

former the *corpus* is relatively much longer than in the latter. Among the higher primates the chimpanzee is in this respect least removed (average 43) from the primitive condition, as found in monkeys; man ranks a close second with an average index of 46, and the siamang represents the most specialized type, its index averaging 82. This extreme shortening of the *corpus sterni* in *Symphalangus syndactylus* is clearly shown in figure 6. It is a well-known fact that in this proportion there exists a marked secondary sex difference in man, according to which women have a relatively shorter *corpus* than men. Krause (1897), *e. g.*, obtained an average of 46.2 in males and one of 54.3 in females. As stated by Martin (1928) the same sex difference has been found in primitive human races. In the adult orang-utans measured by the author this index averages 55.5 in 10 males and 58.1 in 17 females. These figures indicate the existence in an ape of the same sex difference which was found in man.

The second index of table 14 expresses the relative breadth of the *manubrium*. In general this breadth is greater in apes and man than in the lower primates, but *Ateles* forms a rare exception among the latter, having an unusually broad manubrium. Man possesses the lowest average index among all higher primates, the gibbon forming the opposite extreme (see also fig. 6).

The relative breadth of the *corpus sterni* varies in the lemurs and monkeys of table 14 between 13 and 17, but in the higher primates between 21 and 57. Generic differences in this index are much more pronounced than in that expressing the shape of the *manubrium*. The exceptionally broad *corpus* of the orang-utan is seen at once in figure 6. In this ape the index ranges individually up to 79.6, which means that the breadth of the *corpus* can be as much as four fifths of the length.

The average values for the different *Hylobatidae* in table 14 prove that in regard to all three proportions the genus *Hylobates* forms one extreme and the species *Symphalangus syndactylus* the opposite extreme, while the species *S. klossi* shows values which are closer to the former than to the latter. In regard to the sternum, therefore, *S. klossi* resembles the gibbons much more closely than the large siamang. It may here he recalled that a very similar conclusion was reached in a previous chapter in regard to the vertebrae.

The variability of these sternal indices is very great, but the index dealing with the *manubrium* alone is somewhat more stable than the other two which refer to the *corpus*. This is in agreement with the experience gained from human skeletons in which the sternum, and especially the *corpus*, is considered one of the most variable parts. The high variability of the proportions of the sternum in apes is best examplified by the conditions in orang-utans, of which the largest series was available. In this ape the length-breadth index of the *manubrium* ranges from 105 to 187 and the relative range of variations (maximum *minus* minimum in per cent of average) amounts to 60.1. The relative range of the length - breadth index of the *corpus* is 69.6, and that for the *corpus* length - *manubrium* length index even 94.3.

CLAVICLE

Of the four largest primates the chimpanzee has on an average the shortest clavicle and the gorilla (*G. beringei*) the longest (see table 15). In individual cases, however, the orang-utan can considerably surpass the gorilla in this respect. The maximum of the latter is 190 mm., but in four out of 14 adult male orang-utans, measured by the author, the clavicle was longer, reaching in one case (Nat. M. 145301) 213 mm., which may represent the highest clavicular length of all primates.

As shown by the examples in figure 7, the clavicles of the gibbon and of the siamang differ in their curvature from those of all the other higher primates. In adult orang-utans the clavicles are with few exceptions practically straight, whereas in the chimpanzees a pro-

TABLE 15

The Absolute Length (in Mm.) and Two Indices of the Clavicle in Primates. The First of the Indices Gives the Middle Circumference of the Clavicle in Percentage of the Length of the Clavicle, the Second Index Expresses the Length of the Clavicle in Percentage of the Length of the Humerus. The Individual Values for Gorillas Are Listed in Table XII, Those for the Other Higher Primates Are Not Listed Separately.

PRIMATE	SPECIMENS	LENGTH OF CLAVICLE	CIRCUMFER. OF CLAVICLE / CLAVICLE L.	CLAVICLE L. / HUMERUS L.
Galago spec.?	1	18	17.8	44.5
Lemur mongoz	1	32	33.1	43.1
Cebus capucinus	1	37	24.2	36.5
Alouatta seniculus	1	84	20.2	47.7
Ateles geoffroyi	1	57	31.6	29.1
Pithecus rhesus	1	56	32.1	39.2
Colobus angolensis	1	61	....	37.4
Pygathrix potenziani	1	48	....	36.9
Hylobatidae (average)	8 (ad.)	85.6	21.8	39.0
Pongo pygmaeus (average)	43 (36 ad.)	159.0	23.2	48.1
Pan spec.? (average)	11 (9 ad.)	117.7	25.6	42.7
Gorilla gorilla (average)	15 (juv. & ad.)	151.1	28.0	37.1
Gorilla beringei (average)	6 (juv. & ad.)	163.8	25.1	43.3
Homo (White) (average)	6 (ad.)	147.3	26.6	47.7

nounced S-shaped curve is present in the majority of the cases. The latter type of clavicle occurs occasionally in young orang-utans (No. 3, fig. 7) and is fairly common in man, but in these it is rarely as marked as in chimpanzees. In most gorillas the clavicle is nearly straight, except for the acromial end, which is bent in varying degrees. The series of gorilla clavicles in figure 7 has been arranged according to the increasing degree of bending in the acromial end, which reaches its extreme in No. 16. The *facies articularis acromialis* is directed nearly parallel to, or at a sharp angle with, the longitudinal axis of the clavicle in the majority of gorillas (see, *e. g.*, Nos. 9 & 16), but stands nearly perpendicular to this axis in many human beings (see, *e. g.*, Nos. 18 & 19).

The relative thickness of the clavicle, as expressed by the percentage relation between the circumference in the middle of the bone and its length, varies in the few lower primates in table 15 between 18 and 33.

Among higher primates this proportion varies less, namely between 21 and 32. According to the average values the gibbons and orang-utan have a more slender clavicle than the chimpanzee, man, and gorilla.

The last column of table 15 shows the relation in length between the clavicle and the humerus. This proportion, which was introduced by

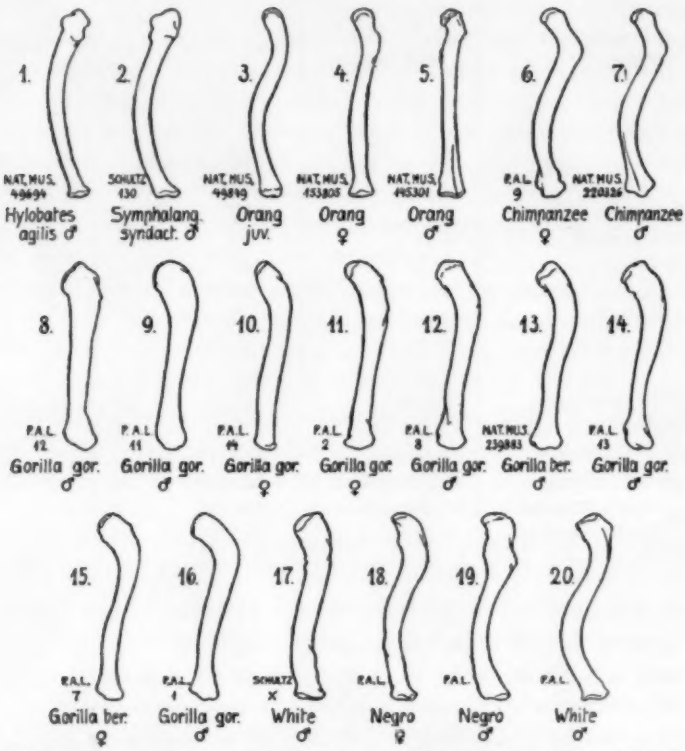


FIG. 7. LEFT CLAVICLES, SEEN FROM BELOW, OF HIGHER PRIMATES. All reduced to the same length and all standing on the sternal ends (drawn with dioptrograph).

Broca, is comparatively constant within the same race or species. In this, as in the last index, there exists no clear difference between the lower and the higher primates. Among the former *Ateles*, which so frequently represents an extreme, has by far the lowest index, undoubtedly on account of the great lengthening of its humerus. The same reason explains the low index in the *Hylobatidae* among the higher primates. In the orang-utan, however, the index is high in spite of the very long humerus, so that it may be concluded that in this ape the

clavicle has become unusually lengthened. This observation can be directly correlated with the fact that in no other primate are the shoulders situated so high above the suprasternal notch as in the orang-utan. For this reason the clavicles of orang-utan are not directed horizontally as in man, but they diverge upward at a steep angle. Under these conditions it is evident that the extraordinary length of the clavicle in orang-utan does not indicate an unusual breadth between the shoulders, but is due rather to the unusually high position of the shoulders.

The difference of 6.2 between the average values of the clavicular-humeral index in *Gorilla gorilla* and *G. beringei* is significant because in the former the individual values range from 32.7 to 39.0 and in the latter from 42.0 to 44.1 (see table XII). Even in infantile stages the two gorilla species differ in this respect. In the mountain gorilla the clavicle averages in length 164 mm., in the lowland gorilla only 151 mm. (table 15). The length of the humerus, on the other hand, averages 389 mm. in the former and 404 mm. in the latter (table 21). It is seen that *Gorilla beringei* has not only a longer clavicle but also a shorter humerus than *Gorilla gorilla*. The individual variations in the proportion between the lengths of these bones do not overlap in the two species. For this reason the index under discussion has a taxonomic value in the study of gorillas, provided additional specimens confirm this finding, which could be based upon only a limited series of *Gorilla beringei*.

It should be mentioned that all the measurements, discussed in this chapter, were taken on the left side, except in a few cases in which the left clavicles were missing or broken. The asymmetries in the length of the clavicle are recorded in a later chapter.

SCAPULA

To express the complicated and very variable shape of the primate scapula by means of measurements requires a carefully selected and accurate technique. The following measurements, adopted by the author, are illustrated in drawing No. 28 in figure 9.

Direct measurements:

Morphological length = from center of glenoid cavity (*A*) to a point on the vertebral margin, lying in the middle of the medial end of the scapular spine (*B*).

Spine length = from the last-mentioned point (*B*) to the most distant point on the *acromion* (*F*).

Acromion breadth = greatest width of *acromion* (*L* - *K*) perpendicular to the longitudinal axis of the acromial process.

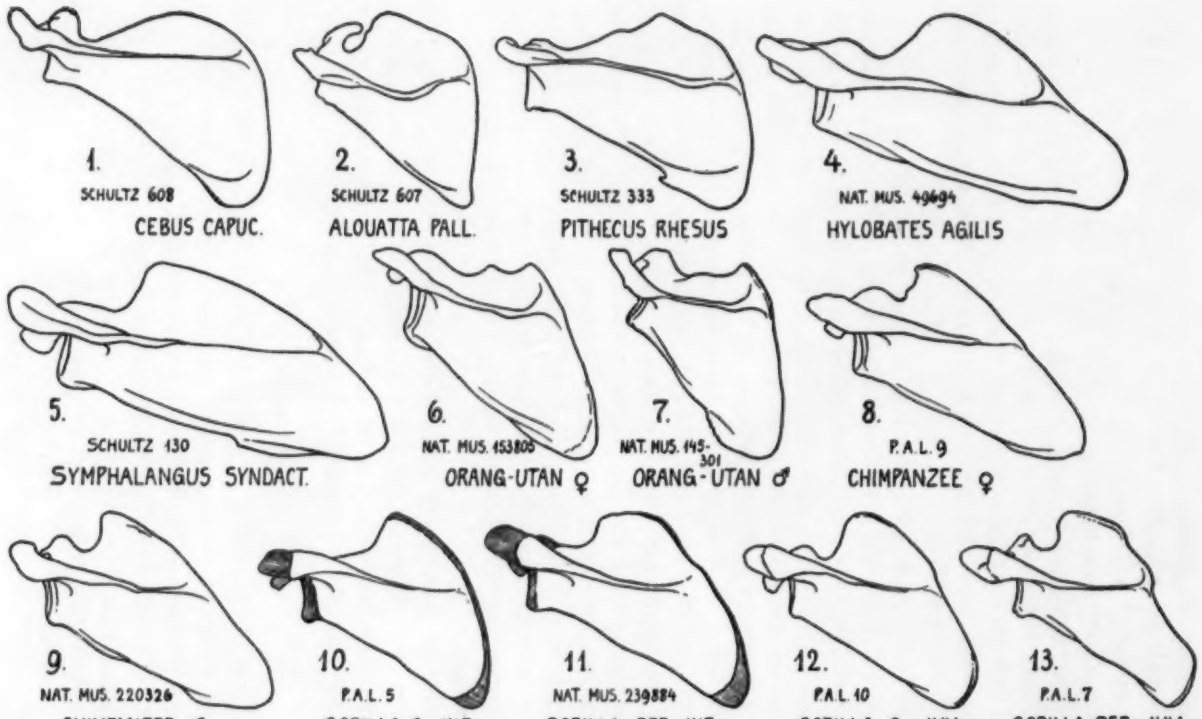


FIG. 8. LEFT SCAPULAE OF PRIMATES REDUCED TO THE SAME HEIGHT AND ORIENTED SO THAT THE MORPHOLOGICAL LENGTH (LINE *A* - *B*, FIG. 9, NO. 28) IS DIRECTED HORIZONTALLY (DRAWN WITH DIOPTROGRAPH). All specimens are adult, except Nos. 10 to 13. The shaded portions in the infantile scapulae Nos. 10 and 11 are cartilaginous. This series is continued in figure 9.

except Nos. 18 to 15. The shaded portions in the illustrations [illegible] in figure 9.

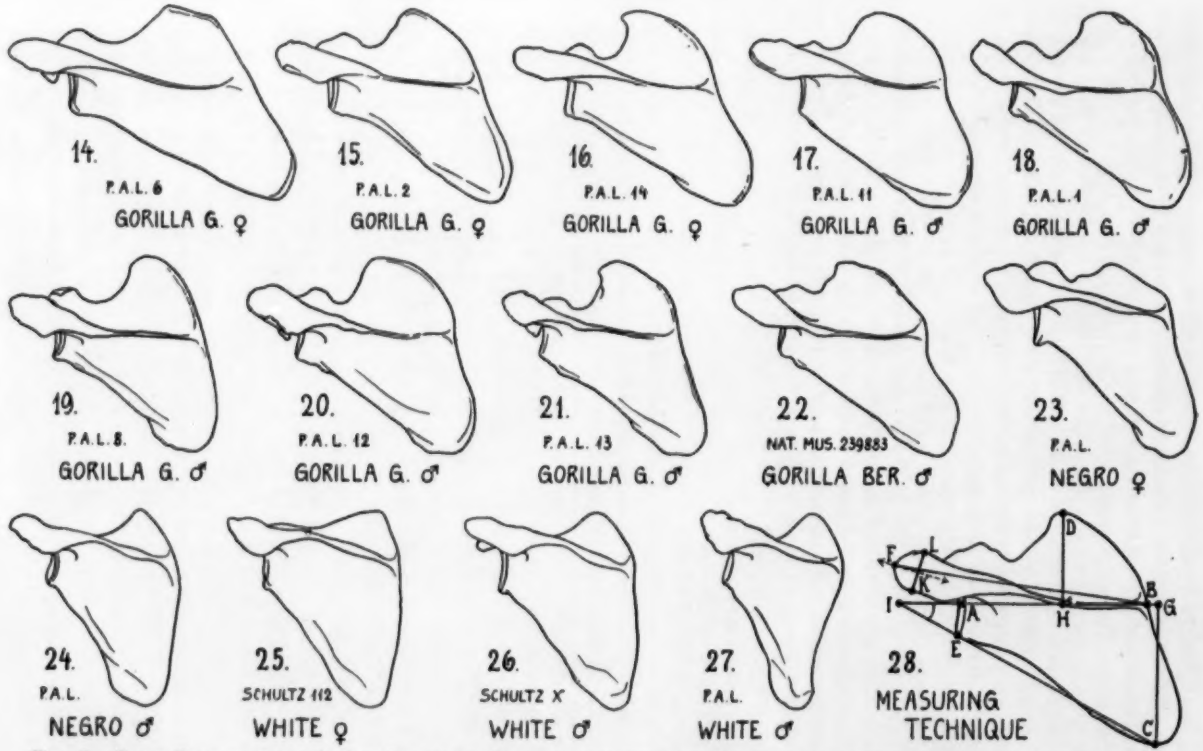


FIG. 9. LEFT SCAPULAE OF ADULT PRIMATES REDUCED TO THE SAME HEIGHT AND ORIENTED AS IN FIGURE 8 (DRAWN WITH DIOPTROGRAPH). This series is continued from figure 8. The measuring technique, illustrated by No. 28, is explained in the text.

In a careful study Frey (1923) has given excellent reasons for abandoning the old method of measuring the breadth of the scapula (direct, between superior and inferior angles) and for substituting the projective breadths of the supraspinous and infraspinous fossae (perpendicular to the morphological length). In regard to these breadth measurements the author has followed the method of Frey with a slight modification in technique which introduces greater accuracy. This modification consists chiefly in the use of the three-legged divider, an instrument described in a former paper by the author (1929). The ends of the three legs of this divider are placed at the three points *A*, *B*, and *D* of a scapula (see fig. 9, No. 28). The instrument is then transferred to a piece of paper in which the sharp points puncture three small holes, which stand in exactly the same relation to each other as the three points on the scapula itself. This process is repeated for the points *A*, *B*, and *C* as well as for *A*, *B*, and *E*. By placing the divider on the paper in such a way that the points *A* and *B* coincide every time, one obtains the exact position of all the scapular measuring points in one figure. The various points are connected by straight lines in the fashion shown in figure 9, No. 28. It is now possible to measure on paper the following:

Breadth of *fossa supraspinata* (*D* - *H*)
Breadth of *fossa infraspinata* (*C* - *G*)
Axillo-spinal angle (*C* - *I* - *B*)

TABLE 16

Averages of the Morphological Length, Some Proportions, and the Axillo-spinal Angle of the Scapula of the Primates Listed in Table XIII

PRIMATE	SPECIMENS	MORPHOLOG. LENGTH	MORPHOLOG. LENGTH / FOSSA INFRASPINATA + SUPRASPINATA BR.	FOSSA SUPRASPINATA / FOSSA INFRASPINATA	FOSSA INFRASPINATA / MORPHOLOG. LENGTH	FOSSA SUPRASPINATA / MORPHOLOG. LENGTH	SPINE LENGTH / MORPHOLOG. LENGTH	ACROMION BREADTH / SPINE LENGTH	AXILLO-SPINAL ANGLE
Cebus	1	45	102.2	25.7	77.8	20.0	122.1	12.2	34.0
Alouatta	1	60	77.9	45.3	88.3	40.0	123.2	12.1	38.0
Ateles	1	55	87.3	50.0	76.4	38.2	123.5	10.3	26.0
Pithecus	1	74	105.6	45.8	64.9	29.7	118.8	13.6	28.0
Papio	1	117	142.7	32.3	53.0	17.1	113.7	9.8	30.0
Pygathrix	1	47	81.1	23.4	100.0	23.4	119.0	10.7	36.0
Hylobates (several spec.)	10	62	128.4	79.2	44.3	34.5	125.8	13.9	16.9
Symphalangus klossi	2	54	110.2	60.6	56.4	34.3	127.7	13.8	20.0
Symphalangus syndactylus	4	75	116.7	84.0	47.2	39.5	128.9	15.9	15.3
Pongo pygmaeus	2	99	69.1	25.4	115.6	29.5	134.2	13.4	39.5
Pan spec.?	2	102	83.0	77.4	68.5	52.5	134.5	14.1	22.5
Gorilla gorilla	9	150	76.5	63.0	80.8	50.7	138.4	16.9	30.7
Gorilla beringei	2	141	70.5	57.5	90.2	51.9	144.8	18.3	32.5
Homo (Negroes)	16	104	66.1	40.5	108.5	43.8	137.7	19.5	45.5
Homo (Whites)	12	99	63.3	39.6	114.1	44.5	137.2	19.3	49.2

The percentage relations or indices between these measurements are named in table 16. The first of these ("scapular index") expresses

the morphological length in relation to the added breadths of the two scapular fossae. The higher this index the relatively narrower is the scapula perpendicular to its spine and *vice versa*. Frey (1923) has clearly demonstrated that in general a proportionately narrow scapula permits a smaller range of movement of the upper limb than a relatively broad scapula. In this connection it is interesting to find that of all the primates, listed in table 16, white man has the broadest scapula, as indicated by the minimum index of 63, whereas the opposite extreme is found in a baboon with an index of 143. Among the higher primates the *Hylobatidae* have much narrower scapulae than the large apes and man. The scapular index of the former ranges between 97 and 152 and that of the latter between 56 and 93 (see table XIII). The values for orang-utan and for some gorillas fall well within the range of variations for man (56 – 75, and according to Frey among 129 whites 54 – 78). The author's values for this index agree very closely with those given by Frey (1923), except in the case of the large siamang, for which Frey obtained in 7 specimens an average of only 104 (range: 103 – 106), whereas the author in 4 specimens obtained an average of 117 (range: 97 – 130). In both these series of *Symphalangus syndactylus*, however, the average values fall considerably below those for any species of *Hylobates*. Frey has already commented at length (pp. 316 & 317 and table XVII) on this marked difference between what she calls "different subspecies of *Hylobates*," according to which the siamang has a relatively broader scapula than any of the gibbons.

The second index in table 16 ("Spinal fossae index") shows the relation in breadth between the upper and the lower spinal fossa. In all the primates studied by Frey (1923) and by the author the supraspinal fossa is narrower than the infraspinal one, except in one *Hylobates leuciscus* in which both fossae were equally broad (table XIII). The *Hylobatidae* in general show the highest values for this index among all primates, whereas the orang-utan represents the opposite extreme, besides some of the lower primates, and this in spite of the fact that the shoulder must have a very similar function in both the extreme brachiators—the gibbon and the orang. This striking difference between these two apes in regard to the proportionate development of the scapular fossae is also clearly shown in figure 8.

The length—breadth index for the fossa infraspinata ranges among higher primates from an average of 44 to one of 116, whereas the corresponding index for the fossa supraspinata ranges only from 29 to 52. It can be stated, therefore, that the supraspinous portion of the scapula

is very much less subject to evolutionary change than the infraspinous portion. The breadth of the latter surpasses the morphological length in man and in orang-utan, since both have average infraspinous indices of over 100. Neither Frey nor the author found this index to rise above 100 in any other primate. The maximum individual variation in the gorilla (92 according to the author, 95 according to Frey) reaches the minimum variation in man (93 according to Frey and the author). In regard to the supraspinal index the average values for man are greatly surpassed by those for the chimpanzee and the gorilla, whereas all the other primates examined have lower values than those of human races.

It can now be stated that in regard to all the four scapular indices discussed so far, the values for man overlap those found in other primates. A study of the averages in table 16 supports furthermore the conclusion that in general there exist much greater differences in the scapula between the gibbon and the other higher primates than between man and the three large apes.

The angle between the axillary border of the scapula and the morphological length, which corresponds roughly to the base of the scapular spine, (axillo-spinal angle) varies in the primates studied between 11° in a gibbon and 58° in a man (table XIII). The minimum value in man is 37°, the maximum in other primates 42°, found in an orang-utan. On an average this angle is highest in man, particularly in whites, and lowest in the siamang, in which the spine runs nearly parallel to the axillary border (see fig. 8, No. 5).

The percentage proportion between the spine length and the morphological length expresses the relative amount to which the acromial process reaches beyond the glenoid cavity. This index varies between 114 and 123 in lower primates, on an average between 126 and 129 in *Hylobatidae*, and between 123 and 145 in the large apes and man. It can be stated, therefore, that the acromial process is comparatively short in monkeys, somewhat longer in gibbons, still longer in orang-utan and chimpanzee, and longest of all in man and gorilla.

Similarly, it is found that the relative breadth of the acromion (last index in table 16) is greater in the higher primates than in the monkeys, and greatest of all in gorilla and man. The latter two primates, therefore, possess the most extensive protection of the shoulder joint by means of the longest and broadest acromial process.

A study of the figures in table XIII shows convincingly that all the scapular indices vary individually a great deal, though not as much as the proportions of the sternum. The spinal fossae index, for instance, ranges in man between 25 and 51 and in *Hylobates* between 58 and 100. This marked variability is also seen from the drawings in figures 8 and 9. The series of gorilla scapulae contains as striking differences between individual variations as does the series of human scapulae. The outlines of the fossa supraspinata are not alike in any two gorillas and the contour of the vertebral border of the gorilla scapulae varies, just as in man, from convex, to straight, and even to concave. Human scapulae with a straight or concave vertebral border have been named "scaphoid" by Graves, who used to believe (1911) that they are connected with congenital syphilis and later (e. g. 1924) maintained that they represent a symptom of degeneracy. In view of the fact that scaphoid types of scapulae are quite common in gorillas it is apparent that even Graves' later and modified view is at least far too generalized. Frey (1924) denies the existence of any evidence for a correlation between the scaphoid scapula and degeneracy and concludes from her elaborate investigations on human bodies that specialized functions, due in turn to differing professions, are responsible for the variations in the shape of the scapula in general and in the contour of the vertebral margin in particular. Since these are found to vary in gorilla at least as much as in man, it is extremely difficult to share the belief of Frey that differing functions are *the* cause of these variations. The author, however, is thoroughly convinced by the beautiful studies of Frey that variations in the mode of muscle insertion (*e. g.* of the *M. rhomboideus*) can influence the contour of the scapula. Such muscular variations, naturally, occur in gorillas as well as in man and may in both primates be at times correlated with skeletal variations.

A significant result of the persistent studies by Graves (1910–1924) consists in his demonstrating the hereditary nature of scapular variations. On this basis it can be understood that *Gorilla beringei* differs from *Gorilla gorilla* in regard to the formation of the vertebral border of the scapula. Scapulae No. 13, figure 8, and No. 22, figure 9 show the irregular contour of this border in the mountain gorilla, which seems to be characteristic of this species, since it was also well marked in the four specimens of the American Museum of Natural History. In all these scapulae the portion of the vertebral border at the root of the scapular spine bulges beyond the general direction of this border. This difference between the two gorilla species seems to be already

developed in infants, as shown by a comparison between Nos. 10 and 11 in figure 8. It will be noted that the cartilaginous zone at the vertebral border is continuous in the infantile lowland gorilla and interrupted in the young mountain gorilla. This finding on only two infants can merely suggest a possible cause for the constant difference between the adults.

PELVIS (AND SACRUM)

The three main pelvic elements, the ilium, ischium, and pubis, do not meet in the center of the acetabulum, as is frequently stated, but in a point situated more ventrally. This point lies in all primates

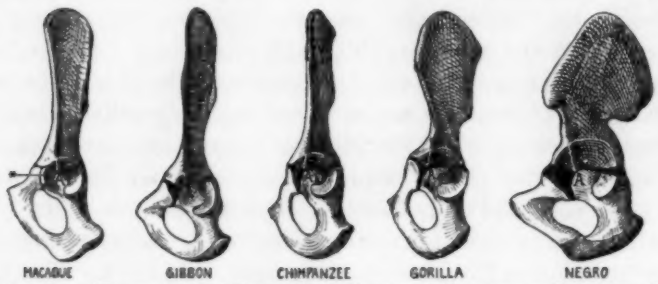


FIG. 10. SIDE VIEWS OF THE LEFT OSSA COXAE OF INFANTILE PRIMATES SHOWING THE POINT IN WHICH THE ILIUM, ISCHIUM, AND PUBIS MEET. This point (*A*) lies in all forms at the inner border of the *facies lunata* and in the direction of the acetabular border of the *ilium*. An *os acetabuli anterius* in the macaque is marked with an asterisk.

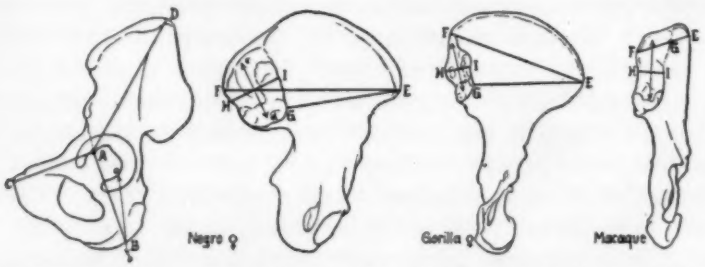


FIG. 11. PELVIC MEASUREMENTS SHOWN IN THE LEFT OSSA COXAE OF A NEGRO, A GORILLA, AND A MACAQUE. This measuring technique is explained in the text.

approximately at the intersection of the inner edge of the *facies lunata* with a straight line prolonging the lower part of the acetabular border of the ilium downward. This is shown by the examples of infantile pelves in figure 10, in which the point under discussion is marked with *A*. Starting from this central point the three pelvic radii are measured directly on the left *os coxae* in the following manner (see fig. 11):

1. Ilium length = point *A* to most distant point on iliac crest (*D*)
2. Ischium length = point *A* to a point (*B*) in which the axis of the ischium (*a* - *b*) crosses the ischial tuberosity
3. Pubis length = point *A* to upper end of pubic symphysis (*C*, "Symphysion")

The inner views of the innominate bones of man, gorilla, and macaque, given in figure 11, show not only widely differing development in width of the ilium of primates, but also striking differences in the proportion between the iliac fossa and the sacral surface of the ilium. In speaking of the "sacral surface" the author considers in this study the *facies auricularis* and the *tuberositas iliaca* as one region, corresponding to the area of the (cartilaginous and ligamentous) sacro-iliac articulation. To characterize these features of the ilium the following three breadth dimensions were measured:

4. Ilium width = greatest distance between the anterior superior and the posterior superior iliac spines (*E* - *F*)
5. Fossa iliaca width = from the anterior superior iliac spine to the nearest point on the sacral surface (*E* - *G*), but never above the direction of the ilium width
6. Sacral surface width = greatest width (*I* - *H*) perpendicular to and through the center of the longitudinal axis of this area (*c* - *d*).

It is frequently assumed that concavity of the fossa iliaca is a human peculiarity. In order to obtain some exact data by means of which to settle this question, the following measurement has been selected:

7. Fossa iliaca depth (respectively height) = greatest depth (or height) of the iliac surface below (or above) the line of the fossa iliaca width (*E* - *G*). If this surface is convex the value for the "height" is preceded by a +; if the surface is straight the resulting measurement will be 0; and if the iliac fossa is concave the value for the "depth" will be accompanied by a *minus* sign. This measurement is easily and accurately taken by means of a sliding compass with three parallel arms, of which the middle one can be lengthened or shortened. The author used the "Koordinatenzirkel" described by Martin (1928, vol. II, p. 591).

The most important percentage relations between these pelvic measurements are named in table 17, which contains the average values of the indices. The data from which these averages were obtained are listed in detail in table XIV. In the latter table will be found a greater variety of lower primates than in the former, but the proportion between the ilium width and ischium length is not included, since the individual values of this index are of little significance.

The first proportion in table 17 gives the length of the ilium in percentage of the length of the ischium. With an average of only 139, man is characterized by the relatively shortest ilium among all primates, the opposite extreme being found in the large siamang with an average index of 252. It is significant that the human ilium does not acquire its extreme shortness until late in growth, as shown by the

TABLE 17

Averages of the Ilium Length (in Mm.) and of the Proportions of the Pelvis of the Primates Listed in Table XIV

PRIMATE	AGE	SPECIMENS	ILIUM LENGTH	ILIUM LENGTH / ISCHIUM LENGTH	PUBIS LENGTH / ISCHIUM LENGTH	ILIUM WIDTH / ILIUM LENGTH	ILIUM WIDTH / ISCHIUM LENGTH	FOSSA IL. WIDTH / SACRAL SURF. W.	FOSSA IL. DEPTH / FOSSA IL. WIDTH
Oedipomidas	adult	1	30.0	166.7	83.4	40.0	66.7	2.5	0
Cebus	adult	2	63.5	184.0	81.2	37.8	69.6	32.4	0
Ateles	adult	1	100.0	227.0	102.2	42.0	95.5	152.5	− 3.4
Pithecus	adult	2	90.0	204.3	91.1	37.2	76.0	80.9	+14.1
Papio	adult	1	127.0	208.3	83.6	48.0	100.0	120.6	+ 5.7
Hylobates (several spec.)	ad.	23	86.8	231.1	94.6	50.9	117.8	224.1	− 4.7
Symphalangus klossi	adult	2	84.5	222.4	94.7	59.7	126.3	282.3	−11.8
Symphalangus syndactylus	adult	4	108.8	251.9	111.8	62.0	156.1	278.1	− 9.2
Pongo pygmaeus	adult	2	157.0	189.9	98.8	77.4	147.0	268.0	− 7.0
Pan spec.?	infant	1	85.0	197.5	60.5	50.6	100.0	235.7	0
Pan spec.?	adult	2	173.5	199.4	81.7	62.2	124.0	304.8	− 4.6
Gorilla gorilla	infant	1	105.0	184.2	80.7	79.0	145.5	320.8	− 4.9
Gorilla gorilla	adult	9	216.0	186.1	95.1	89.7	167.0	393.8	−15.0
Gorilla beringei	infant	1	108.0	200.0	81.5	75.9	151.7	280.8	− 6.8
Gorilla beringei	adult	6	239.3	195.5	101.9	86.0	168.1	352.6	−15.8
Homo	fetus & newborn	4	33.7	152.9	92.5	113.1	173.0	120.6	− 7.5
Homo (Negro & White)	adult	15	127.0	139.0	89.3	121.6	169.2	152.3	−13.4

fact that the index of fetuses is much higher than that of adults. In other primates there exists no such marked age change in this respect (see also the data for *Pithecus* in table XIV). The ilium of adult man is exceptionally short not only in relation to the ischium, but also when compared with the length of the trunk and head. The latter comparison has been studied by Waterman (1929), who found that the ilium length amounts to only 16 per cent of the "body length" (from center of *acetabulum* to vertex) in man, but to anywhere from 24 to 28 per cent in the other higher primates.

The relation in length between the pubis and the ischium is comparatively constant in the primates studied. Among adults the chimpanzee has the relatively shortest pubic bone and the siamang the relatively longest one. The value for man stands much nearer to the minimum than to the maximum of this index. In the chimpanzee and in the gorillas the pubis grows more intensively than the ischium, so that the index increases very considerably with advancing age. In man, however, no such growth change can be demonstrated.

The third index in table 17 shows the relative width of the ilium. It is quite evident that there exists a general evolutionary trend to broaden the primate ilium. In lower primates the ilium width amounts to less than 50 per cent of the ilium length, in higher primates, on the other hand, to more than 50 per cent, with the exception of some specimens of *Hylobates*. Man is the only primate in whom the width of the ilium surpasses the length, all human indices lying above 100, whereas all indices of monkeys and apes lie below 100. This phylogenetic tendency to increase the width of the ilium is clearly shown by the examples of primate pelves in figure 12. It has also been convincingly demonstrated by Straus (1929), who studied the same problem with slightly different methods on very extensive primate series. Straus' averages for the relative width of the ilium

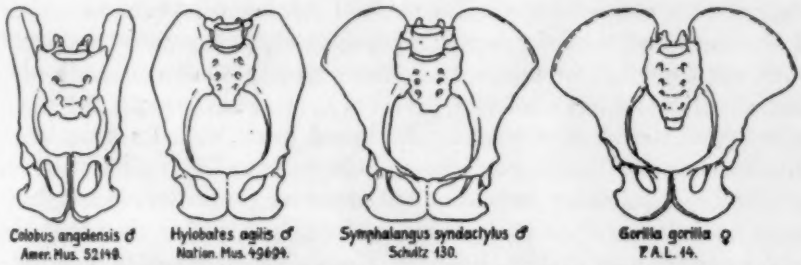


FIG. 12. EXACT FRONT VIEWS OF THE PELVIS IN SOME ADULT PRIMATES. All reduced to the same total height (drawn with dioptrograph).

agree in principle with those obtained by the writer. According to both authors the gorilla approaches man most closely in regard to this proportion, even though they are separated by a gap which is not bridged by individual variations. In this connection it should be noted also that in chimpanzee, in both species of gorilla, and in man, the relative width of the ilium increases with advance in age and, therefore, repeats in ontogeny what must have happened in the course of evolution.

Since the human ilium, as shown above, has become extremely shortened, it must be concluded that the unusually large length-width index of the human ilium is not so much due to an actual increase in width as rather to this decrease in length. This assumption is supported by a study of the next index in table 17, which expresses the ilium width in percentage of the ischium length, which is phylogenetically more conservative than the length of the ilium. Like the former

index, this second relative ilium width increases in general from the primitive marmoset to the large apes and man. It is found that the width of the ilium increases with advancing age not only in relation to the ilium length but also in percentage of the ischium length. In regard to this second index, however, the increase occurs in the African apes only and not in man. Whereas the first relative ilium width showed a very marked difference between man and gorilla (averages 122 and 90 respectively), the second is practically the same in the two primates (averages 169 and 168 respectively). From this must be concluded that the ilium of man has not really become broader than that of gorilla but has become only very much shorter.

The pelvic indices, discussed so far, have also a certain taxonomic value, since they permit nearly always a diagnosis in regard to the genus in the family of the *Hylobatidae* and even one in regard to the species in the genus *Gorilla*. The marked difference between the pelvis of *Hylobates* and that of *Symphalangus syndactylus* is at once apparent from the drawings in figure 12. These examples demonstrate also that the siamang has already a pelvis of typical anthropoid ape character, particularly in regard to the broad ilium with its prominent anterior superior iliac spine, whereas the pelves of the gibbons have not yet departed so far from the more primitive condition of catarrhine monkeys. Based upon these findings alone, it is readily seen that the pelves pictured by Boltze (1926, fig. 8) can not be those of *Symphalangus syndactylus*, as claimed by that author, but must belong to some species of *Hylobates*.[5] This deduction is furthermore supported by the fact that the ilium length of Boltze's specimens ranges from 73 to 86.5 mm. In the author's series of *Hylobates* this measurement varies in adults between 77 and 97 mm., whereas in the series of siamangs it varies between 104 and 120 mm. Additional differences between the pelves of the various gibbon species on one hand and of the siamang on the other, are present in all the proportions listed in table 17. The most pronounced difference exists in the relative width of the ilium, particularly when expressed in percentage of the ischium length. According to the indices in table 17, the pelvis of *Symphalangus klossi* resembles in general that of *Hylobates* somewhat more closely than that of *S. syndactylus*. This is particularly true if the

[5] This species is most likely *leuciscus*, since Boltze's three specimens were sent from Weltevreden, Java. The writer has obtained several specimens of *H. leuciscus* from the same place. Java, furthermore, contains no other species of either *Hylobates* or *Symphalangus*.

last two indices of that table are disregarded on account of their especially high variability together with the fact that only two specimens of *S. klossi* could be examined.

The pelvis of *Gorilla beringei* differs from that of *G. gorilla* in regard to the length of the ilium. In percentage of the ischium length it amounts on an average to 195.5 in the former and to only 186.1 in the latter. The absolute length of the ilium varies in adult females between 220 and 231 mm. in the mountain gorilla and between 191 and 204 mm. in the lowland gorilla; in adult males it ranges from 260 to 268 mm. in the former and only from 216 to 238 mm. in the latter. Even the giant *Gorilla gorilla*, P. A. L. 8, has a much shorter ilium than the smallest of the *G. beringei* males (see table XIV). The claim that the mountain gorilla possesses an unusually long ilium can be only tentative since five adults represent too small a series to permit definite conclusions. Nevertheless these preliminary findings strongly suggest that the two groups of gorilla have diverged in their specializations.

The last index in table 17 expresses the greatest height of the curvature of the iliac fossa in percentage of the width of this fossa. Among lower primates this fossa is most frequently entirely flat, but it can be markedly convex, except in infantile specimens. *Ateles* seems to be the only lower primate in which a concavity is indicated and it is noteworthy that this coincides with the relatively broadest iliac fossa. Among the higher primates a convex fossa iliaca is still found in an occasional gibbon (2 out of 23 specimens) and chimpanzee, but in all the others this fossa has become concave. This concavity is much more pronounced in adults than in infants and is greater in *Symphalangus syndactylus* than in *Pongo* and *Pan*. The highest degree of concavity is attained by *Gorilla*, who surpasses man in regard to the average, as well as to the maximum individual variation.

The relation in width between the iliac fossa and the sacral surface differs tremendously in different primates. In a marmoset (*Oedipomidas*), for instance, the width of the fossa amounts to only 2.5 per cent of the width of the sacral surface, whereas in adult gorilla this percentage relation can rise to 477. This index lies always below 160 in lower primates, on an average above 200 in *Hylobatidae* and orang-utan, above 300 in adult chimpanzee and gorilla, but again below 160 in man (see table 17 and fig. 11). This general evolutionary trend to shift this proportion in favor of the iliac fossa is undoubtedly due to the above noted tendency to broaden the ilium, which affects almost exclusively the part of the ilium which is not required for attachment

to the spine. The same reasons are connected with the finding that this index increases with advancing age in all primates. The following discussion represents an attempt to explain the condition in man, which forms a striking exception to the general rule, that the sacral surface of primates remained relatively constant while the iliac fossa tended to become steadily broader.

That man represents an exception among higher primates was found by means of the proportion between the fossa iliaca width and the sacral surface width, which averages 152 in man and, for instance, 394 in the lowland gorilla. The low value of the former must be due either to an unusually narrow fossa or to an exceptionally broad sacral surface or, finally, to a combination between these two conditions. The correct answer is found by means of the following sample test: The fossa iliaca width in percentage of the ischium length amounts on an average to 100.2 in adult man and to 130.8 in adult *Gorilla gorilla;* the sacral surface width in percentage of the ischium length averages in man 66.4 and in the same series of gorillas 33.0. These figures suffice to support the conclusion that the iliac fossa of man is relatively narrower than that of one of the apes (man: gorilla = 1:1.3), whereas the sacral surface of man is much broader than that of apes (man: gorilla = 1:0.5). It must be recalled in this connection that the total width of the ilium in percentage of the ischium length was found to be practically the same in man and gorilla, namely 169 in the former and 167 in the latter. This equal development in relative width was accomplished in the gorilla by the great lateral expansion of the iliac fossa, but in man by the dorsal enlargement of the sacral surface. The latter increase is also shown by the figures in table 18, particularly by the width of the sacral surface, which averages 62 mm. in man and only 45 mm. in the much larger gorilla. The fact that the sacral surface of the large apes is much longer than that of man is unquestionably connected with the above demonstrated shortening of the human ilium. As shown by table 18, the approximate area of the entire surface for the connection between spine and ilium is not much larger in gorilla than in man, but is much larger in the latter than in orang-utan and chimpanzee. This seems particularly significant when it is recalled that in regard to general body size, as characterized by weight, man surpasses the male chimpanzee on an average very little, if at all, and is slightly inferior to fully grown orang-utans, whereas the male gorilla averages more than twice the body weight of man. It is hardly to be doubted that the area of the sacro-iliac

TABLE 18

The Length, Width, and Approximate Area of the Sacral Surface of the Ilium in Adult Male Higher Primates

PRIMATE	COLLECTION	DIMENSIONS OF SACRAL SURFACE (MM.):		APPROXIMATE AREA OF SACRAL SURFACE (SQ. CM.)
		Length	Width	
Pongo pygmaeus	Nat. M. 145301	*83*	*38*	*30.8*
Pan spec.?	Nat. M. 220326	*70*	*31*	*22.3*
Gorilla gorilla	P. A. L. 12	94	42	39.2
Gorilla gorilla	P. A. L. 13	98	48	45.1
Gorilla gorilla	P. A. L. 8	111	46	50.6
Gorilla gorilla	P. A. L. 11	115	46	50.7
Average of the four *Gorilla gorilla*	.....	*104*	*45*	*46.4*
Homo (Negro)	P. A. L.	63	57	36.0
Homo (Negro)	P. A. L.	64	59	37.8
Homo (Negro)	Sch.	65	65	42.1
Homo (White)	Sch.	70	68	48.0
Average of the four *Homo* (Negro & White)	.....	*65*	*62*	*41.0*

articulation is in general influenced by that part of the body weight which is at this place transmitted from the trunk to the leg. Quite generally speaking, only half the weight of the trunk rests on the sacral surfaces of quadrupeds, and in brachiating primates only the weight of the lower limbs is held at the junction between spine and ilium. In erect man, on the other hand, the entire weight of the trunk, head, and upper limbs bears on the sacro-iliac articulations. These articulations in man must be capable of supporting at least twice as large a share of the body weight as in gorilla. With this consideration in mind it is readily understood that an erect man with a body weight of about 165 lbs. requires 41 sq. cm. of sacral surface, whereas a quadrupedal gorilla of 360 lbs. or more has a sufficiently strong sacro-iliac articulation with 46 sq. cm. of surface, and a chimpanzee of at least 150 lbs. needs only 22 sq. cm.

The writer has become convinced by these studies that the large sacral surface of man, which had to be acquired with the evolution of erect posture, did not develop at the expense of the region of the iliac

fossa, but represents rather a new growth process, increasing the total width of the ilium in a dorsal direction (see figs. 11 and 13).

Mechanical factors have been responsible not only for the size and position of the *pars sacralis* of the ilium but have also influenced the pelvis in other ways. This is shown, for instance, in the exact lateral views of the pelves in figure 13. Seen from this direction the *os coxae* of the macque differs from that of the gorilla chiefly in regard to the width of the fossa iliaca and the angle between the axis of the pubis and that of the ilium. This angle has already been fully discussed by Weidenreich (1913). Macaque and gorilla are very similar in regard to the relative distance between the sacro-iliac articulation and the *acetabulum*. It will be noted at once in figure 13 that this particular distance is proportionately much longer in the siamang and

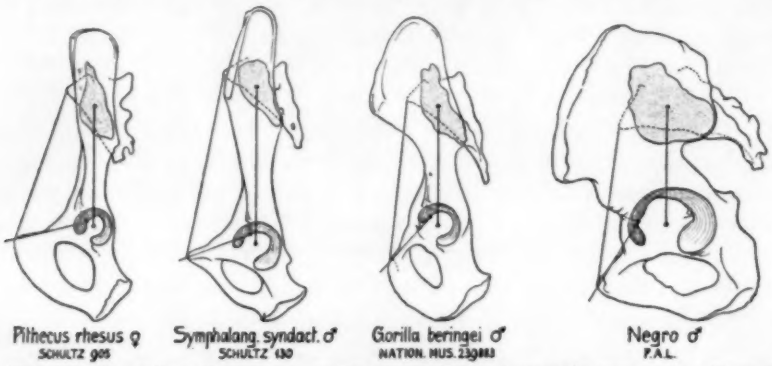


FIG. 13. LEFT SIDE VIEWS OF THE PELVES OF SOME ADULT PRIMATES, ALL REDUCED TO APPROXIMATELY THE SAME HEIGHT AND ALL DRAWN WITH THE DIOPTROGRAPH EXACTLY PERPENDICULAR TO THE MIDSAGITTAL PLANE. The midsagittal outline of the *sacrum* and the contour of the sacro-iliac articulation (including ligamentous portion, dotted area) were drawn by means of Martin's diagraph. The drawings are oriented so that the lines connecting the center of the *acetabulum* with that of the sacro-iliac articulation area stand perpendicular.

very much shorter in man. These conditions can be understood with the following consideration in mind. Locomotion in the macaque and the gorilla takes place chiefly in the quadrupedal fashion, although both make use of brachiation to a limited extent; the gibbon moves most of the time by brachiating, whereas man moves exclusively by erect walking. The weight of the trunk, acting on the sacro-iliac articulation, is supported by the femur in the *acetabulum*. In quadrupedal primates the weight acts in front of the support (see also fig. 14) and the lever from the articulation to the *acetabulum* has to maintain a conservative length. In the extreme brachiator the weight

FIG. 14. SIDE VIEWS OF THE TRUNK AND THIGH OF EMBALMED PRIMATES IN WHICH THE SOFT PARTS OF ONLY THE LEFT SIDE HAVE BEEN REMOVED TO SHOW THE POSITION OF THE PELVIS IN ITS EXACT NATURAL RELATION TO THE TRUNK. The straight lines represent the direction of the *ischium*, of the *pubis*, and of the *symphysis*.

of the lower limb pulls on the *acetabulum* in a caudal direction, thereby having lengthened the portion of the ilium underneath its attachment to the spine. In bipedal man, on the other hand, exactly the opposite condition prevailed, the sacro-iliac articulation having been pushed down toward the *acetabulum*, thereby shortening the entire ilium.

This crude presentation of conditions, which in reality are undoubtedly much more complicated, purports chiefly to call attention to the evidently and necessarily close connection between mechanical factors and evolutionary changes in the primate pelvis, a connection which exists nowhere more pronouncedly than in the pelvis of man.

The last consideration of the pelvis deals with its exact position in the trunk. Weidenreich (1913) claimed that the backward bending of the *pars sacralis* of the ilium in man necessitated a rotation of the entire pelvis in order to bring the center of the sacro-iliac articulation, *i.e.*, of the weight of the trunk, perpendicularly above the center of the *acetabulum*, so that the weight rests directly above the supporting femora. In this way he tried to explain the well-known "tilting forward" of the human pelvis. The author can not agree with this view, since the same result—if attained at all (compare the human pelves in figs. 13 & 14)—could have been more consistently accomplished by bending the ilium forward in such a fashion that its axis would form a smaller angle with the axis of the pubis, instead of the largest angle among all primates, as it actually does according to Weidenreich's own figures.

In studying the natural position of the pelvis within the trunk (by exposing one side and leaving the other side embedded in the flesh) it is found that this position is practically the same in all primates, except man. As shown by the examples in figure 14, the direction of the ischium and that of the pubic symphysis follows in general the direction of the longitudinal axis of the trunk in the chimpanzee and in the gibbon, whereas in man the former two directions are more nearly perpendicular than parallel to the trunk axis. The pubic axis forms roughly a right angle with the trunk axis in the chimpanzee and gibbon, but one of about 150° in man. Figure 14 shows very clearly that in man the sacrum forms rather the roof than the dorsal wall of the pelvic cavity, while the symphyseal region functions more as a floor than as a ventral wall. In these respects man differs radically from other primates. It is very significant that in the brachiating and, therefore, erect gibbon the pelvis has the same position within the trunk as in the largely quadrupedal chimpanzee, but a position entirely

different from that in erect man. The entire trunk of any of the brachiators turns to an upright position in the *acetabulum*, whereas only the presacral portion of the trunk of man has acquired the upright position, and this chiefly by bending in the lower part of the lumbar region of the spine and not at all by turning in the *acetabulum*. It is difficult to bring this finding into agreement with the view of Morton (1926) and others that brachiation with its vertical posture opened the way automatically for the erect posture of modern man.

As shown by figure 14, the ischial and pubic bones (and even the sacrum) of man have the same position in relation to the thigh as in chimpanzee with a quadrupedal pose. Indeed, it appears that at least the lower part of the pelvis is much more closely fixed by the limb than by the trunk and that this part retained in man the position characteristic of a quadruped. This, in turn, implies that the human trunk became erect only above the sacro-iliac articulation. A very similar view has been expressed by Friedenthal (1910), who regards the position of the human pelvis as a primitive inheritance from quadrupedal ancestors. Westenhöfer (1929) is the most emphatic advocate of this theory and claims bluntly that "man is to this day a quadruped in regard to the position of his pelvis."

The last part of this chapter is devoted to certain proportions of the sacrum, which is a part of the pelvic girdle. The following three measurements were taken on the sacrum:

Length = greatest, ventral, straight length of the sacrum in the midsagittal plane (fig. 16, *A* - *B*) (measurement 2 of Martin, 1928, p. 1001).

Width = greatest transverse diameter of the sacrum between the ventral edges of the *facies auriculares* (measurement 5 of Martin, p. 1001).

Height of arc = greatest height of ventral, midsagittal curvature of sacrum above base formed by the length of the sacrum (fig. 16, *C* - *D*) (measurement 6 of Martin, p. 1001). This height is best measured with the "Koordinatenzirkel" of Martin.

The averages of the two indices, formed with these measurements, are listed in table 19. The width of the sacrum surpasses the length only in man among all the higher primates. The sole exception to this rule was found in a female *Symphalangus klossi*, in which the width amounted to 103 per cent of the length. This specimen, however, possesses only four sacral vertebrae, whereas man averages over five. Man has in proportion to the number of sacral vertebrae the relatively broadest sacrum of all primates, a fact which is also shown by the examples in figure 15. Individual variations of the length-width index

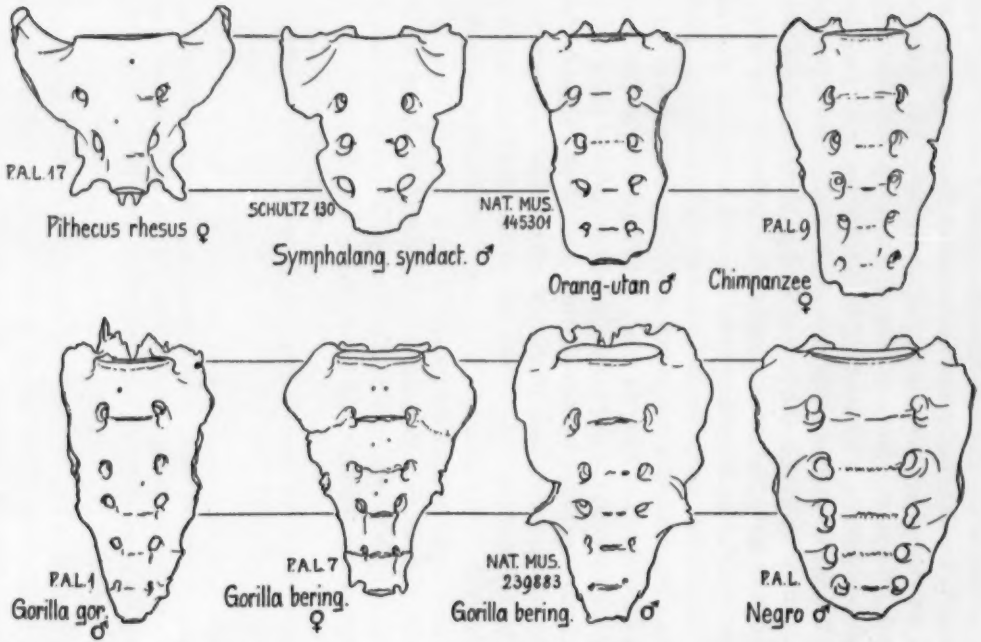


FIG. 15. FRONT VIEWS OF THE SACRA OF PRIMATES, ALL REDUCED TO THE SAME HEIGHT OF THE FIRST THREE SACRAL VERTEBRAE (DRAWN WITH DIOPTROGRAPH).

of sacra with at least five vertebrae range in gorilla to as much as 80 and in male negroes to as little as 85. Negroes have on an average a relatively narrower sacrum than whites, as shown by the figures in table 19, as well as by those of Martin (1928), who records 91 as the average index of male negroes and 112 as the average of male whites.

TABLE 19

Averages of the Number of Vertebrae, the Length-width Proportion, and the Relative Height of the Midsagittal Curvature of the Sacrum of Adult Higher Primates

PRIMATE	SPECIMENS	VERTEBRAE	WIDTH / LENGTH	HEIGHT OF ARC / LENGTH
Hylobates (several spec.)	20	4.4	86.0	4.0
Symphalangus klossi	2	4.5	93.0	5.8
Symphalangus syndactylus	4	4.3	87.7	5.5
Pongo pygmaeus	2	5.0	67.7	8.5
Pan spec.?	2	6.0	67.6	5.2
Gorilla gorilla	12	5.5	69.9	10.9
Gorilla beringei	5	5.8	71.9	10.3
Homo (Negro)	6	5.5	98.0	14.7
Homo (White)	4	5.3	113.1	20.9

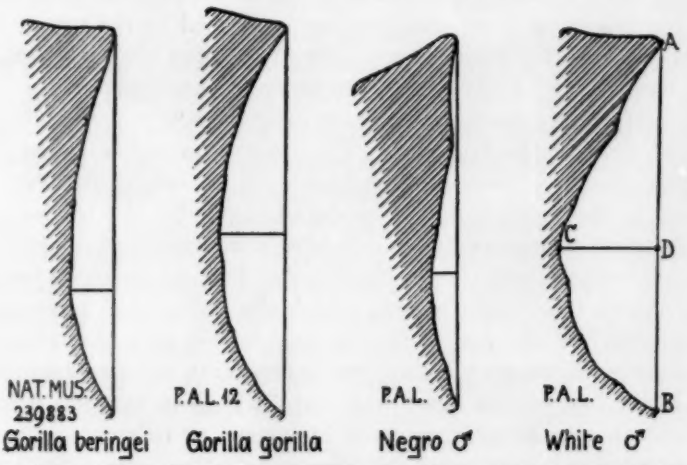


FIG. 16. MIDSAGITTAL SECTIONS THROUGH THE SACRA OF GORILLA AND OF MAN SHOWING DIFFERENT DEGREES OF CURVATURE (DRAWN WITH DIAGRAPH).

The height of the arc in percentage of the length of the sacrum measures the degree of the sagittal concavity of the sacrum. Figure

16 shows that in some gorillas the sacrum can be much more curved than in some human beings. The maximum relative height of the sacral arc is in gorillas 16.8, whereas the minimum in negroes amounts to only 9.3. On an average this index ranges from 4 to 6 in *Hylobatidae;* it amounts to 5 in chimpanzee, 8 in orang-utan, and 11 in gorilla. Man possesses the highest average, namely 15 in negroes and 21 in whites. According to Radlauer (1908) the same index averages 9.6 in the large apes, 18.1 in negroes and 23.6 in whites.

These figures permit the generalized conclusion that among primates with at least five sacral vertebrae chimpanzee has retained the straightest and narrowest sacrum, orang-utan follows as a close second, while the gorilla approaches man in these respects more than do the other apes. The sacrum of negroes is clearly more primitive and anthropoid in character than that of whites, whose sacrum is the most highly specialized among all primates in regard to its width as well as to its concavity.

It should be mentioned, finally, that by far the longest sacrum of all primates was found in the giant gorilla, P. A. L. 8, whose sacrum measures 173 mm. in length.

HUMERUS AND RADIUS

The studies on the long bones of the limbs, to be discussed in this and the following three chapters, are restricted to the proportions in length between the bones representing the upper arm, forearm, thigh, and leg. While taking the necessary measurements the author recorded in many cases the presence or absence of a perforation of the *fossa olecrani* of the humerus. These notes on the so-called *foramen supratrochleare* (*foramen intercondyloideum*) are briefly discussed before passing to the proportions. The data in table 20, though based upon mostly small series, permit the following conclusion. A supratrochlear foramen exists rarely in the *Hylobatidae,* but occurs quite frequently in the three large apes, among which the orang-utan possesses it in the majority of the cases. In the anthropoid apes the frequency of this foramen increases with age and is greater in females than in males. The latter two results agree with the findings in man, in whom this perforation was never discovered in fetuses or infants and in whom women possess it very much more frequently than men. For instance, Koganei (1894) noted the foramen among Japanese in 28.1 per cent of women and in only 7.3 per cent of men, and among Ainus in 22.2 per cent of women and in 5.6 per cent of men. According to Hult-

TABLE 20

The Frequency of the Foramen Supratrochleare in the Humerus of Higher Primates

GENUS	AGE	SPECIMENS	PRESENT IN CASES:	
			Absolute	Percentage
Hylobates	adult	10	1	10
Symphalangus	adult	6	0	0
Pongo	juvenile	8	5	62
Pongo	adult ♀	25	21	84
Pongo	adult ♂	17	13	76
Pan	juvenile	3	0	0
Pan	adult ♀	7	3	43
Pan	adult ♂	8	3	37
Gorilla	infantile	2	0	0
Gorilla	juvenile	3	1	33
Gorilla	adult ♀	9	5	56
Gorilla	adult ♂	10	4	40

krantz (1897) the foramen occurs in Swedes in 14.8 per cent of women and in 4.7 per cent of men. As shown by Martin's (1928) compilation from the literature, a *foramen supratrochleare* has been found in over 50 per cent of the cases in Veddas and in certain American Indians, but in not more than 10 per cent of the cases in different series of modern whites. This perforation, therefore, can be at least as common in man as in the chimpanzee. Slomann (1926) has reached the conclusion that at least in *Gorilla* the foramen is closed again in old males, but the writer has seen it wide open in two specimens of very evidently advanced age. Most authors agree in assuming that this perforation is caused by mechanical factors, connected with hyperextension of the forearm, and that its presence in man has no atavistic significance, as had been claimed by Wiedersheim (1908). Schinz (1922) found the foramen repeatedly in the same human family, so that it may be assumed that at least the occurrence of mechanical factors favoring a perforation of the *fossa olecrani* after juvenile life is hereditary.

Four long bones of the limbs were measured by the following methods, which have been clearly pictured by Mollison (1911, figs. 4 to 7):

Humerus length = greatest distance between *caput humeri* and *capitulum humeri* parallel to the longitudinal axis of the bone.

Radius length = greatest distance between *capitulum radii* and styloid process parallel to the longitudinal axis of the bone.

Femur length = greatest distance between great trochanter and lateral condyle parallel to the longitudinal axis of the bone.

Tibia length = greatest distance between the middle of the edge of the medial condyle and the *malleolus medialis* parallel to the longitudinal axis of the bone.

The length of the radius expressed in percentage of the length of the humerus is called the brachial index. In prosimians this index lies usually above 100, though in individual cases it can go as low as 95 (Mollison, 1911, p. 295). In platyrrhine monkeys the index averages about 95 (table 21) and ranges according to Mollison from the rare value of only 84 to 104, the genus *Ateles* usually having indices slightly above 100. The lower catarrhines possess as a rule higher indices than the platyrrhines (see table XV), the average of the former lying above 100. The minimum value of only 87 stands quite isolated among the large series of Old World monkeys measured by Mollison, whereas the maximum of 115 is, according to the same author, approached by the indices of many other specimens. As shown by table 21, the *Hylobatidae* have on an average by far the highest brachial index among all *Simiae* and one which is surpassed only by some highly specialized prosimians. Man, on the other hand, is characterized by the lowest average brachial index among all primates, this index being closely approached by only that of the gorilla. These notes and the data in table 21 can be summarized by stating that in general the radius is longer than the humerus in prosimians and in the lower catarrhines, and is slightly shorter than the humerus in platyrrhines. Among the higher primates the radius greatly surpasses the humerus in length in all gibbons and siamangs. The two bones are, on an average, of the same length in orang-utan, and the radius is somewhat shorter than the humerus in the chimpanzee. Gorilla and man, finally, are the only primates in which the radius is relatively very short. This is also clearly shown by figure 17, which demonstrates at the same time the range and distribution of the variations in this index. It can be seen at a glance that the range of variations in every genus of the higher primates overlaps extensively the range of the nearest genus. This is particularly striking in the case of man and gorilla. Rare individual variations in man can actually reach beyond the upper limit (85.2) of the range in *Gorilla gorilla*, since the writer found a brachial index of 87.6 in a perfectly normal negro woman. The range for chimpanzee does not cross the 100 line in figure 17 but the author (1930) has recorded in another paper an adult chimpanzee with a brachial index of 101.4, a value which lies above the average of orang-utan. It is of

TABLE 21

Averages of the Humerus Length (in Mm.) and of the Limb Proportions of the Adult Primates Listed in Tables XV to XIX. The Data for Man Are Not Recorded in Detail; the Proportions of Ainus Were Calculated from the Measurements by Koganei (1894), *the First Series of Negroes and of Whites Were Measured in Part by Dr. Straus and in Part by the Author, the Second Series, of Which Only the Crural Indices Are Given, Were Measured by the Author for Another and As Yet Unpublished Study.*

PRIMATE	SPECIMENS	HUMERUS LENGTH	BRACHIAL INDEX	CRURAL INDEX	INTERMEMBRAL INDEX
Prosimians	2	.....	103.7	94.3	67.7
Platyrrhine monkeys	10	.....	94.9	94.6	87.6
Catarrhine monkeys	12	.....	100.8	91.2	88.6
Hylobates lar	7	228.6	113.4	88.7	132.7
Hylobates pileatus	6	227.5	111.5	89.2	123.9
Hylobates leuciscus	3	236.3	112.1	86.3	127.0
Hylobates agilis	3	228.0	115.7	88.1	131.6
Hylobates (all species)	24	226.4	113.3	88.5	128.3
Symphalangus klossi	2	201.5	113.6	88.5	125.8
Symphalangus syndactylus	13	269.2	111.3	86.3	148.2
Pongo pygmaeus	66	343.7	100.7	91.9	143.8
Pan spec.?	29	299.8	92.6	83.7	107.7
Gorilla gorilla	51	404.3	80.7	80.3	117.0
Gorilla graueri	5	419.0	76.2	78.0	116.2
Gorilla beringei	5	389.0	85.5	81.5	112.4
Homo (Ainu)	49	289.4	76.9	86.6	71.8
Homo (Negro)	11	303.6	75.6	86.3	69.9
Homo (Negro)	76	.....	.....	85.9	.....
Homo (White)	11	305.7	75.3	84.3	70.9
Homo (White)	62	.....	.....	84.0	.....

particular interest to note that the individual variations in man (three different races, 71 individuals), containing only one species, range over 17 index units, whereas those in the family *Hylobatidae* range over practically the same extent (18 index units), although this series contains two genera and at least six species.

As shown by table 21 and figure 17 the three types of gorilla differ in regard to the brachial index. *Gorilla beringei* has the relatively longest forearm and *Gorilla graueri*, which is frequently regarded as a

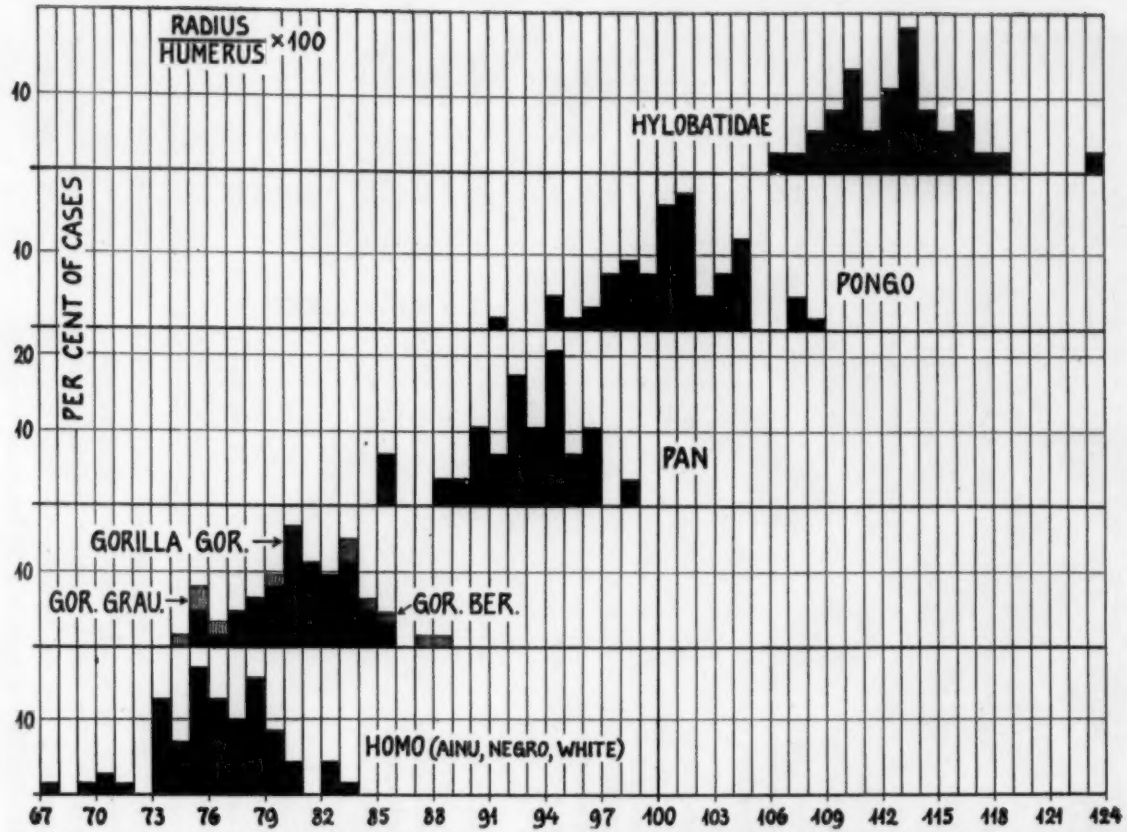

RADIUS / HUMERUS ×100
PER CENT OF CASES
HYLOBATIDAE
PONGO
PAN
GORILLA GOR.
GOR. GRAU.
GOR. BER.
HOMO (AINU, NEGRO, WHITE)
67 70 73 76 79 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124

FIG. 17. FREQUENCY POLYGONS FOR THE VARIATIONS IN THE BRACHIAL INDEX OF THE ADULT HIGHER PRIMATES LISTED IN THE TABLES XVI TO XIX AND 21. The perpendicular, white, broken lines show the positions of the averages.

mere subspecies of *G. gorilla*, the proportionately shortest one. The average of *G. graueri* lies even below the average of Ainus.

TABLE 22

Age Changes in the Average Limb Proportions of the Higher Primates Listed in Tables XVI to XIX

PRIMATE	AGE	SPECIMENS	BRACHIAL INDEX	CRURAL INDEX	INTERMEMBRAL INDEX
Hylobates	juvenile	7	105.1	87.2	121.7
Hylobates	adult	24	113.3	88.5	128.3
Symphalangus syndactylus	juvenile	2	109.0	87.5	143.0
Symphalangus syndactylus	adult	13	111.3	86.3	148.2
Pongo pygmaeus	infantile	4	97.0	91.5	143.0
Pongo pygmaeus	juvenile	10	98.9	92.2	143.7
Pongo pygmaeus	adult	66	100.7	91.9	143.8
Pan spec.?	juvenile	7	91.2	82.6	109.3
Pan spec.?	adult	29	92.6	83.7	107.7
Gorilla gorilla	infantile	4	82.9	83.2	121.3
Gorilla gorilla	juvenile	4	81.2	81.5	118.7
Gorilla gorilla	adult	51	80.7	80.3	117.0
Gorilla beringei	infantile	1	79.8	75.5	121.1
Gorilla beringei	juvenile	2	80.0	78.7	113.5
Gorilla beringei	adult	5	85.5	81.5	112.4

The figures in table 22 demonstrate the fact that the brachial index increases with age in all the higher primates, except apparently the lowland gorilla. The author has shown in a previous paper (1926, table 11) that man follows this general rule, inasmuch as his index also increases with advancing growth. The same paper contains the data (table 12) supporting the claim that the greatest ontogenetic change in this index occurs in the primates with the relatively longest forearms in adult life. In a fetus of *Hylobates pileatus*, *e. g.*, the brachial index amounts to only 87.2, but in adults of the same species this proportion has changed to an average of 111.5. In a much younger gibbon fetus (*H. concolor*, sitting height 21.5 mm.) this index is even only 76.3. Among very extensive series of monkey and ape fetuses the author

IN THE TABLES XVI TO XIX AND 21. The perpendicular, white, broken lines show the positions of the averages.

has never seen a single specimen in which the radius surpassed the humerus in length, but he (1924, 1926) has found it an almost universal rule for primates that the forearm grows more intensively than the upper arm. A radius somewhat shorter than the humerus is ontogenetically, and in all likelihood phylogenetically, the original condition. A radius surpassing the humerus in length occurs late in ontogeny and represents a new specialization in phylogeny. Such a specialization is usually associated with the evolutionary trend to lengthen the entire upper extremity, which itself is accomplished chiefly by this intensive ontogenetic increase of the length of the radius. An extreme length of the entire arm, and especially of the forearm, has developed not only in the typical brachiators, such as *Ateles*, *Hylobates*, *Symphalangus*, and *Pongo*, but also in such quadrupedal forms as the baboons in which the arms had to become as long as the legs (which are proportionately long in the lower catarrhines).

The figures in table 23 demonstrate the fact that no sex difference exists in the brachial index of siamangs and anthropoid apes. According to Martin (1928) this index is lower in women than in men. This author's compilation of the upper arm-forearm indices and the humero-radial indices in human races shows that in 34 instances women had the lower values, but that in 10 other instances the women had higher indices than the men. The average absolute length of the humerus is

TABLE 23

Sex Differences in the Average Limb Proportions of the Adult Higher Primates Listed in Tables XVI to XIX

PRIMATE	SEX	SPECIMENS	HUMERUS LENGTH	BRACHIAL INDEX	CRURAL INDEX	INTERMEMB. INDEX
Symphalangus syndactyl.	♀	4	266.8	111.5	84.8	149.5
Symphalangus syndactyl.	♂	6	275.8	110.2	87.0	148.8
Pongo pygmaeus	♀	30	324.7	100.8	92.1	144.6
Pongo pygmaeus	♂	32	364.5	100.9	91.8	143.1
Pan spec.?	♀	12	289.3	92.3	84.6	107.5
Pan spec.?	♂	13	312.6	92.7	83.5	107.5
Gorilla gorilla	♀	21	367.8	80.7	80.9	117.2
Gorilla gorilla	♂	30	429.9	80.7	79.9	116.8

in all higher primates greater in males than in females. The most marked difference exists in the gorilla, the orang-utan showing almost as great a sex difference. The siamang and chimpanzee, on the other hand, differ comparatively little in the two sexes in regard to this particular dimension. It is very interesting but difficult to explain that sex differences in size should be so little alike in various primates. In the gorilla the humerus length of adult females varies between 344 and 403 mm., but that of adult males between 402 and 480 mm., *i. e.*, the two ranges barely touch one another (see table XIX). In the siamang, on the other hand, the two ranges overlap very extensively, the humerus length of females varying between 256 and 275 mm. and that of males between 259 and 289 mm. That male gibbons can also be not much larger than female gibbons seems highly probable from the example of the ilium length in adult *Hylobates concolor*, which averages 87.8 mm. in 8 females and only 86.7 mm. in 6 males (table XIV). In the Spider monkey (*Ateles geoffroyi*), finally, the female seems to be actually larger than the male, as shown by the following data: The sitting height of 14 adult females varies between 408 and 518 mm. (average 453 mm.), whereas that of 6 adult males varies between 404 and 466 mm. (average 437 mm.). These specimens were all shot and measured by the author in one locality and all had their complete permanent dentition. On another and much more extensive series of Spider monkeys the author (1926) could demonstrate that the skulls of males are on an average slightly smaller than those of females, whereas in *Alouatta* the skull dimensions of males surpass those of females by 10 per cent. These data must suffice for the present study to support the claim that the amount of secondary sex differences in primates is widely different in various types. These differences, particularly in size, are most pronounced in the gorilla and are in all probability least developed in the gibbon and Spider monkey.

FEMUR AND TIBIA

The length of the tibia in percentage of the length of the femur is the so-called crural index. This proportion has higher average values in prosimians and platyrrhine and catarrhine monkeys than in gibbons, apes and man (table 21). Among the former the index rises frequently above 100 (Mollison, 1911), whereas among all the latter this was found in only one orang-utan (table XVII). The crural index of primates is more stable than the brachial index, the extremes of the former falling less far apart than those of the latter. Decidedly the lowest average

femoro-tibial index among all primates is that of gorilla; the chimpanzee ranks second in this respect and man as well as some *Hylobatidae*, third. It is very interesting to find that the unique lengthening of the lower extremity of man has not changed the proportion between leg and thigh, since this proportion lies roughly in the middle of its range among higher primates.

The postnatal age changes in the crural index, shown in table 22, are not uniform in the different primates; in four instances the index increases with age, but in two other instances it decreases. In a former paper (1926) the author has demonstrated that this proportion increases from early fetal to adult life in man and in gibbon, but that it remains unchanged during growth in the Spider monkey.

As shown by table 23, there exists no significant sex difference in the crural index of siamangs and apes. The figures for man, collected by Martin (1928), also fail to reveal any consistent sex difference in this respect.

RELATION IN LENGTH BETWEEN UPPER AND LOWER EXTREMITIES

The sum of the lengths of the humerus and the radius in percentage of the sum of the lengths of the femur and the tibia form the so-called intermembral index of the skeleton. In all the lower primates the upper extremity is shorter than the lower one, *i. e.*, the intermembral index lies below 100, with the exception only of two specimens of *Ateles paniscus* and two of *Ateles belzebuth*, measured by Mollison (1911), and of two *Alouatta palliata*, measured by the author (table XV). The highest index of these few exceptions amounts to 107.0. The *Hylobatidae* and the anthropoid apes are sharply disginguished from the lower primates by possessing without a single exception intermembral indices above 100. Adult man represents the exception among higher primates by having a very low intermembral index, indeed, the lowest average value among all *Simiae*. This exceptional position of man is clearly shown in figure 18. The index of man is approached most closely by that of chimpanzee, but the gap between the maximum variation of the former and the minimum variation of the latter amounts to 24 index units. In contrast to this it is found that the ranges of variation of all the other genera of higher primates overlap one with another. The data in table 21 show a significant difference between the intermembral indices of the lowland and the mountain gorillas, according to which the latter has the proportionately shorter arms. This difference was discussed in detail in a former paper by the author (1927, fig. 1,

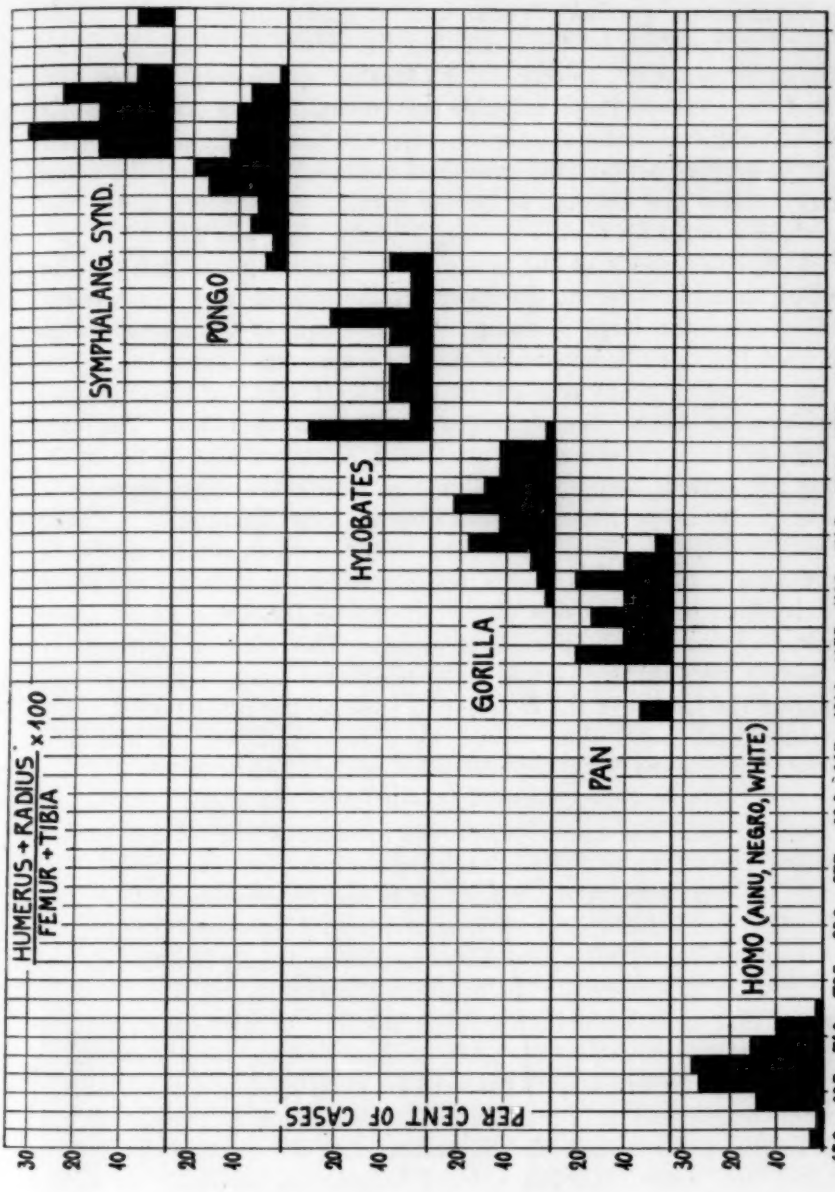


FIG. 18. FREQUENCY POLYGONS FOR THE VARIATIONS IN THE INTERMEMBRAL INDEX OF THE ADULT HIGHER PRIMATES LISTED IN THE TABLES XVI TO XIX AND 21. The perpendicular, white, broken lines show the positions of the averages.

pp. 31 & 32), so that it remains only to add here two new records on adult mountain gorillas. These were obtained on the large males secured in the flesh by the Columbia University-American Museum African expedition. Doctor D. J. Morton generously invited the author to measure these valuable specimens. These measurements will be published in detail later on. Here it is merely mentioned that both these gorillas have intermembral indices (obtained on the outer body!) below the average of *Gorilla gorilla*, but slightly above the previous average for *Gorilla beringei*, namely 113.6 and 115.2.

A valuable result of the study of the intermembral index is the finding that the different species of *Hylobates* have very much lower indices than the large siamang. The averages of the former range between 124 and 133, but that of the latter amounts to over 148. The maximum value of any true gibbon is 136.9 (*H. lar*), but the minimum variation of adult *Symphalangus syndactylus* is 145.0. The two ranges of variation are clearly separated, as shown also by figure 18. This proportion, therefore, is of distinct taxonomic value, since by it alone one is able to distinguish infallibly the large siamang from all the other *Hylobatidae*. Since this difference is very much greater than that between any two gibbon species, the large siamang should never again be classified as merely one of the species of *Hylobates*, as so many authors unfortunately persist in doing. This plea is particularly necessary, because there are so many additional features which clearly separate the largest of the *Hylobatidae* from all the other forms. The intermembral index alone would have been sufficient to find and correct the mistake in the determination of the genus of Boltze's (1926) material. His specimens have indices of 122.8, 125.9, and 126.3, when calculated from the usually employed measurements. These values could never belong to *Symphalangus syndactylus*, but fit only into the range of variations in *Hylobates*. It is very interesting to find that *Symphalangus klossi* stands far removed from *S. syndactylus* in regard to its intermembral index, which averages even slightly less than in the entire series of *Hylobates*. In previous chapters it has been demonstrated that there are several other important features which tend to ally *S. klossi* more closely the gibbons than with the large siamang.

It has been shown that in the extreme hangelers the upper limb has become lengthened until it can amount to as much as 155 per cent of the length of the lower limb and that in man, the exclusively bipedal walker, the lower limb has become lengthened, so that the upper extremity amounts to only 65 per cent or even less of the length of the

lower one. The intermembral index, however, reveals really only the relation in length between the two limbs and by it alone one can not definitely decide whether, for instance, the low index of man is due to an increase in leg length or a decrease in arm length. This question

TABLE 24

The Intermembral Index and the Relative Lengths of the Limbs (from Measurements Taken on the Outer Body) in Embalmed Higher Primates. The Hylobatidae Are All Juveniles Because No Adult Symphalangus Klossi or S. Syndactylus in the Flesh Was Available. The Adult Gorilla Is Specimen No. 1 of the Columbia University-American Museum African Expedition.

PRIMATE	SEX	AGE	COLLECTION	$\frac{\text{HUMERUS + RADIUS}}{\text{FEMUR + TIBIA}}$	$\frac{\text{HUMERUS + RADIUS}}{\text{ANTERIOR TRUNK H.}}$	$\frac{\text{FEMUR + TIBIA}}{\text{ANTERIOR TRUNK H.}}$
Hylobates agilis	♀	juv.	A. Hopk. 36	123.8	174.5	141.0
Hylobates lar	♂	juv.	Nat. M. 253508	126.9	178.0	140.3
Hylobates leuciscus	♀	juv.	A. Hopk. 205	125.0	179.1	143.2
Symphalangus klossi	♀	juv.	Nat. M. 121682	122.0	183.0	150.0
Symphalangus syndactylus	♀	juv.	Amer. M. C. A. 604	143.7	207.8	144.6
Pongo pygmaeus	♂	adult	A. Hopk. 212	141.5	154.3	109.1
Pan spec.?	♂	sub-ad.	A. Hopk. 206	111.2	119.6	107.8
Gorilla beringei	♂	adult	Columbia Univ. 1	113.6	115.2	101.5
Homo (Negro)	♂	adult	A. Hopk.	63.9	110.3	172.7
Homo (Negro)	♂	adult	A. Hopk.	67.7	128.7	190.3
Homo (Negro)	♂	adult	A. Hopk.	63.6	125.4	197.4

can be answered only by studying the relation between the lengths of the limbs and some dimension on the trunk, best of all the anterior trunk height (upper edge of *manubrium sterni* to upper edge of *symphysis pubis*). A preliminary list of these particular proportions is given in table 24. Since the height of the trunk can not be measured in an exact manner on the skeleton, embalmed specimens had to be used, of which only a few have been selected for the present study. The data for the *Hylobatidae* show conclusively that *Symphalangus syndactylus* has actually a proportionately much longer upper limb than either *S. klossi* or any of the species of *Hylobates*, but that the relative length of the lower limb is the same in all these different animals. The large siamang, therefore, has really developed the longest arm of all primates, not only in relation to the length of the lower limb but also in proportion to the height of the trunk. The limbs of the orang-utan have approximately the same percentage relation to one another as in the

siamang, but in relation to the trunk they are very much shorter than in any siamang or gibbon. The three male negroes differ from the other primates by possessing much longer lower limbs in relation to the trunk height. In regard to the relative length of the upper limb, on the other hand, the negroes fall within the range of variations in the other primates. Man's unusually low intermembral index is, therefore, exclusively due to the lengthening of the lower extremity and is not caused by any demonstrable shortening of the upper extremity. Indeed, the latter is proportionately longer in two of the three negroes than in the gorilla and the chimpanzee. This last fact indicates either that the fully grown African apes are not particularly well adapted for brachiation, or else that at least some human races could become just as good brachiators as these apes.

As shown by the data in table 22, the intermembral index increases a little with advancing age in the gibbon and siamang; it remains practically unchanged in orang-utan and chimpanzee, and it decreases somewhat in the gorillas. In none of these higher primates is the change with age very marked, but the age periods considered do not include those of the most rapid growth, *i. e.*, the fetal and early infantile stages. The author has shown in a previous paper (1926) that the intermembral index (formed of the entire lengths of the extremities) of primates is much more uniform in early fetal than in adult life. By means of detailed data he has been able to demonstrate that during the entire growth period this index either decreases in general or else remains practically constant, small increases occurring only during limited periods of development. He found that the entire upper limb length amounts in early human fetuses to 133 per cent of the entire lower limb length; in human newborns this proportion has decreased to 105, and in human adults to 83. This ontogenetic decrease in man is very much greater than in any other primate and continues through postnatal growth. For this and several other reasons the author concluded that the unique lengthening of the human leg took place most likely during relatively recent phases of man's evolution. In his recent book Wood Jones (1929) has attacked this conclusion by arguing that the late ontogenetic increase in the relative length of man's lower limb "shows no more than that the energies of foetal life are centred on the development of the fore end of the body at the expense of the hind end, and that to secure this result the foetal circulation has its peculiar distribution." The writer agrees with Wood Jones' statement: "It is the invariable rule in all Mammals that in intrauterine stages the fore limb

grows faster, becomes more perfected, and more functional than the hind limb. The foetal circulation is arranged in accordance with this happening, . . . " The author has himself contributed some new evidence supporting this well-known rule (in the chapter on the "Law of developmental direction," Schultz, 1926) and has never denied that it could account for at least the early fetal growth changes in the relation in length between upper and lower limb. No law of cephalocaudal growth, however, can explain the fact that this intermembral index changes ontogenetically so very much more in man than in the other primates and particularly the anthropoid apes. Professor Wood Jones will certainly not claim that the fetal circulation of man is essentially different from that in the apes. That Wood Jones' critique of the author's hypothesis is not pertinent, or at least inadequate, is shown also by the following data, which have been restricted to those bearing upon the postnatal growth period alone. The length of the humerus and radius in percentage of the length of the femur and tibia was found to average 83.5 in 10 white newborns, but only 66.2 in 24 white adults. The same proportion amounts to 131.3 in a newborn orang-utan and to 143.8 in adults of this ape. The figures for chimpanzee are 107.0 in a newborn and 107.7 in adults, and those for gorilla are 113.7 in a twelve months old infant and 117.0 in adults. The values for the ape infants are quoted from the author's (1930) most recent publication on anthropoid ape growth and those for the adults are repeated from table 21. These figures prove first of all that even *after* fetal life the intermembral index of man changes very much more than that of the apes. They furthermore show that from birth to adult life the lower limb grows much faster than the upper limb in man, more slowly in orang-utan, and that the two limbs grow at almost the same rate in chimpanzee and gorilla. There exists to-day no other explanation for the striking differences in these growth processes than the assumption that they are due to late phylogenetic changes in the ontogenetic processes of ancestral forms. This claims that the not too distant precursors of orang-utan had relatively shorter arms and the ancestors of man relatively much shorter legs than recent orang-utan or man.

Martin (1928) shows in several tables that in the majority of human races men have higher intermembral indices than women and states that the latter have in general the relatively shorter arms. It is interesting to find in table 23 that other higher primates also have higher intermembral indices in males than in females, although the differences are so small that they can not yet be regarded as very reliable.

TABLE 25

Variation Coefficients and Their Probable Errors of The Limb Proportions in Adult Higher Primates. From the Series Listed in Tables XVI to XIX and for Man from the Series of 49 *Ainus by Koganei* (1894), *from the New and Complete Series of* 22 *Whites and Negroes Used in Table* 21, *and from a Series of* 136 *Whites and Negroes (Measured Only for Crural Index) Studied by the Author for Another and as Yet Unpublished Investigation.*

PRIMATE	SPECIMENS	BRACHIAL INDEX	CRURAL INDEX	INTERMEMBRAL INDEX	AVERAGE
Symphalangus syndactylus	13	2.42 ± 0.32	2.36 ± 0.31	1.84 ± 0.24	2.21 ± 0.29
Pongo pygmaeus	66	3.40 ± 0.20	3.53 ± 0.21	2.45 ± 0.14	3.13 ± 0.18
Pan spec.?	29	3.20 ± 0.28	2.92 ± 0.26	2.99 ± 0.26	3.04 ± 0.27
Gorilla gorilla	51	3.04 ± 0.20	2.70 ± 0.18	2.48 ± 0.17	2.74 ± 0.18
Homo (Ainu, Negro, White)	71	3.86 ± 0.22	2.69 ± 0.15	3.02 ± 0.17	3.19 ± 0.18
Homo (Negro, White)	158	.....	3.28 ± 0.12	.....	.....
Average	..	3.18	2.84	2.56	.....

It remains to consider the degree of variability of the intermembral index and, for comparison, that of the other limb proportions as well. For this purpose the variation coefficients and their probable errors have been calculated for the series of adult higher primates which contain sufficient numbers of specimens to render these coefficients significant. The results of these calculations are listed in table 25. All these coefficients are rather low, indicating a fairly marked degree of stability in these different proportions of the limb bones. On an average the intermembral index is somewhat more constant than either the brachial or the crural index, a result which agrees with previous findings of the author (1926). The limb proportions of the siamang are decidedly less variable than those of the other higher primates, among which man possesses the most variable proportions. The series for man includes only three different races, whereas that for chimpanzee contains at least two or three different species, yet the former series is slightly more variable than the latter. This comparatively high variability of the limb proportions in man is of particular interest because man was found to be unusually stable in regard to the number of vertebrae. Thus we can conclude that the variability of each particular feature or of each group of features can be very different in closely related primates, but that the comparative degrees of variability of all the features of any particular primate are rarely the same. For instance, the author has shown in a previous study (1926) that the cranial features of *Ateles* are much more variable than those of *Alouatta*,

but, as pointed out in a preceding chapter, the opposite relation exists in regard to the variability of the number of vertebrae. In a similar way, *Homo sapiens* was found to have fewer numerical variations in vertebrae than *Symphalangus syndactylus*, but the limb proportions of the former vary considerably more than those of the latter.

ASYMMETRIES

Asymmetries can theoretically be regarded as variations in the two halves of a body. This was shown by the author in three different papers (1926) which proved that asymmetries are as frequent and as pronounced in fetal as in adult life and are particularly marked in such characters as the size of the outer ears. For these and certain additional reasons the conclusion was reached that bilateral differences in function are not, as is frequently claimed, the determining factors in the occurrence of asymmetries. This chapter is devoted to a comparison between man and other primates in regard to the frequency and degree of asymmetry in their limb bones and clavicles.

The absolute as well as percentage frequencies of asymmetries in limb bones are listed in the tables 26 and 27, which combine the author's new data with those recorded in the literature, especially in the classic paper by Mollison (1911). The main results are shown diagrammatically in figure 19. It is seen, first of all, that cases of symmetry are much more frequent in lower primates than in the higher ones. To some limited extent this may be due to the fact that the bones of the former are in general smaller than those of the latter and that an asymmetry in length becomes the more difficult to detect the shorter the bones are. The limb bones of gibbons, however, are very little longer than those of the majority of New and Old World monkeys, among which many are very much larger than the gibbons, yet in spite of this they are more rarely symmetrical in gibbons than in the lower primates. The greatest frequency of symmetry is found in lower primates, in which the right and left radii are of exactly equal length in 40.8 per cent of the cases; the smallest frequency occurs also in the radii, since in orang-utan these bones are symmetrical in only 6.9 per cent of all the specimens.

Asymmetries in the limb bones of lower primates favor one side practically as frequently as the other, as would be expected from random variations in the two halves of the body. It may be mentioned here that asymmetries in the size of the outer ears of man were also found to be as frequently in favor of the left side as in favor of the right

(Schultz, 1926). Among the higher primates the right bones are more frequently longer than the left bones in the upper limb of the gibbon, orang-utan, and, especially, man. The reversed relation exists in the bones of the lower limb, which are most frequently longer in the left

TABLE 26

Asymmetries in the Humerus and Radius of Adult Primates. Absolute and Percentage Frequencies of Cases in Which the Left Bone Is Longer (l >), in Which the Left and Right Bones Are of Equal Length (=), and in Which the Right Bone Is Longer (r >). The Author's Series for Man Includes 105 *Cases Recorded in a Previous Paper* (1918).

PRIMATE	AUTHOR	TOTAL OF CASES	HUMERUS			TOTAL OF CASES	RADIUS		
			l >	=	r >		l >	=	r >
LOWER PRIMATES	Mollison, 1911	79	21	35	23	82	26	38	18
	Schultz	17	9	3	5	16	9	2	5
	TOTAL	96	30	38	28	98	35	40	23
	PERCENTAGE		31.3	39.5	29.2		35.7	40.8	23.5
GIBBON AND SIAMANG	Mollison, 1911	20	7	3	10	18	2	2	14
	Schultz	13	4	2	7	13	7	2	4
	TOTAL	33	11	5	17	31	9	4	18
	PERCENTAGE		33.3	15.2	51.5		29.0	12.9	58.1
ORANG-UTAN	Bardeleben, 1909	8	0	1	7	....	....	....	....
	Mollison, 1911	14	3	4	7	19	5	1	13
	Schultz	35	13	1	21	39	17	3	19
	TOTAL	57	16	6	35	58	22	4	32
	PERCENTAGE		28.1	10.5	61.4		37.9	6.9	55.2
CHIMPANZEE	Bardeleben, 1909	8	5	1	2	3	1	1	1
	Mollison, 1911	11	4	3	4	12	5	5	2
	Schultz	16	6	1	9	16	6	6	4
	TOTAL	35	15	5	15	31	12	12	7
	PERCENTAGE		42.9	14.2	42.9		38.7	38.7	22.6
GORILLA	Bardeleben, 1909	6	5	0	1	1	0	0	1
	Mollison, 1911	15	5	3	7	16	5	7	4
	Schultz	23	14	2	7	24	10	5	9
	TOTAL	44	24	5	15	41	15	12	14
	PERCENTAGE		54.6	11.3	34.1		36.6	29.3	34.1
MAN	Mollison, 1911	18	1	1	16	16	2	1	13
	Schwerz, 1912	91	6	4	81	44	6	7	31
	Schultz	128	29	26	73	23	4	1	18
	TOTAL	237	36	31	170	83	12	9	62
	PERCENTAGE		15.2	13.0	71.8		14.5	10.8	74.7

TABLE 27

Asymmetries in the Femur and Tibia of Adult Primates. For Explanation See Table 26. The Author's Series for Man Includes 103 Cases of Whites and Negroes Measured for Another and As Yet Unpublished Study

PRIMATE	AUTHOR	TOTAL OF CASES	FEMUR			TOTAL OF CASES	TIBIA		
			l >	=	r >		l >	=	r >
LOWER PRIMATES	Mollison, 1911	84	28	30	26	83	26	32	25
	Schultz	15	2	4	9	16	5	4	7
	TOTAL	99	30	34	35	99	31	36	32
	PERCENTAGE		30.3	34.3	35.4		31.3	36.4	32.3
GIBBON AND SIAMANG	Mollison, 1911	20	6	7	7	20	4	9	7
	Schultz	14	5	2	7	14	8	1	5
	TOTAL	34	11	9	14	34	12	10	12
	PERCENTAGE		32.4	26.4	41.2		35.3	29.4	35.3
ORANG-UTAN	Bardeleben, 1909	6	1	0	5	1	0	1	0
	Mollison, 1911	17	5	6	6	17	4	7	6
	Schultz	35	12	10	13	36	18	5	13
	TOTAL	58	18	16	24	54	22	13	19
	PERCENTAGE		31.0	27.6	41.4		40.7	24.1	35.2
CHIMPANZEE	Bardeleben, 1909	8	7	0	1	2	1	1	0
	Mollison, 1911	12	7	2	3	10	3	2	5
	Schultz	14	6	3	5	15	9	1	5
	TOTAL	34	20	5	9	27	13	4	10
	PERCENTAGE		58.9	14.7	26.4		48.1	14.8	37.1
GORILLA	Manouvrier, 1882	6	3	1	2	.....	.....	.....	....
	Bardeleben, 1909	3	2	1	0	2	0	2	0
	Mollison, 1911	16	7	3	6	17	10	5	2
	Schultz	27	11	3	13	24	9	2	13
	TOTAL	52	23	8	21	43	19	9	15
	PERCENTAGE		44.2	15.4	40.4		44.2	20.9	34.9
MAN	Mollison, 1911	35	24	1	10	35	12	5	18
	Schwerz, 1912	124	65	21	38	115	73	12	30
	Schultz	126	57	21	48	123	69	11	43
	TOTAL	285	146	43	96	273	154	28	91
	PERCENTAGE		51.2	15.2	33.6		56.4	10.3	33.3

limb than in the right in chimpanzee and in man. Figure 19 shows that in general this favoring of one side is more pronounced in the upper limb than in the lower, and is most striking of all in the humerus and radius of man. Since the writer (1926) found among 100 human fetuses that the right humerus is already at this age most frequently

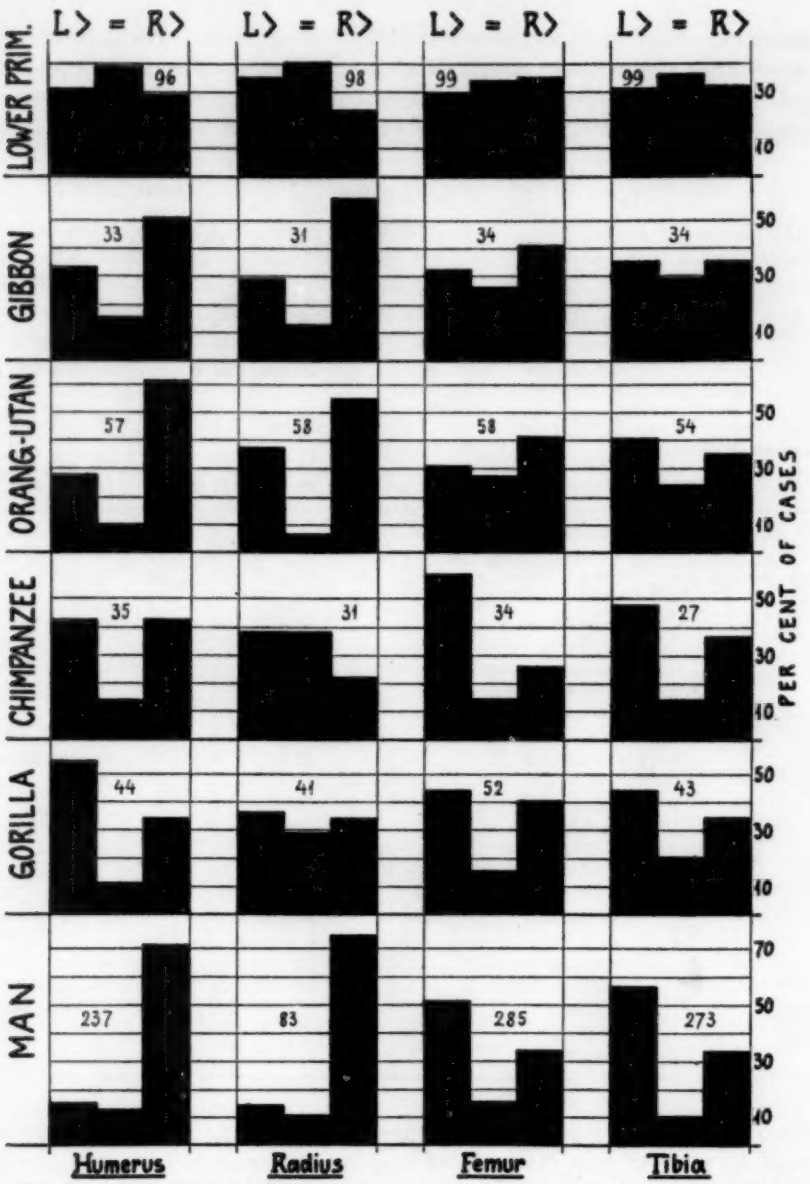


FIG. 19. DIAGRAMMATIC REPRESENTATION OF THE PERCENTAGE FREQUENCIES OF ASYMMETRIES IN THE LIMB BONES OF ADULT PRIMATES. The black columns underneath "L >" represent the relative numbers of the cases in which the left bone surpassed the right one in length. In the same way "R >" indicates asymmetries in favor of the right side; symmetry is marked by a = sign. The small number above each diagram gives the number of specimens used for the construction of the particular diagram (based upon data in tables 26 and 27).

the longer of the two, he can not admit that human right-handedness gives a greater growth stimulus to the right arm, thus causing asymmetries in favor of that side. It seems not impossible, however, that righthandedness is connected with some selective process among the congenital bilateral variations. At any rate, the functional asymmetry, known as right-handedness, is in man correlated with the morphological asymmetry in the length of the limb bones. Should this correlation prove to be a general rule, one could predict from the present data that gibbon and orang-utan are right-handed, though not as commonly so as man, that chimpanzee and gorilla are ambidextrous, and that chimpanzee is as "left-legged" as man. According to Fick (1926), Yerkes (1929), and the author's own observations on live chimpanzees, these apes do use their hands without any regular preference of either the right or the left.

TABLE 28

Percentage Frequencies of Asymmetries in the Length of the Clavicle of Adult Primates. The Series for Man Contains 18 Adult Male Whites from the Western Reserve University (Collection of the Anatomical Laboratory) Which Were Measured by Dr. W. L. Straus, Jr. The Clavicles of the Other Primates Were Measured by the Author.

PRIMATE	TOTAL OF CASES	l >	=	r >
Lower primates	15	47	20	33
Gibbon and siamang	6	67	0	33
Orang-utan	33	45	19	36
Chimpanzee	12	58	25	17
Gorilla	15	27	6	67
Man	39	69	5	26

The asymmetries in the length of the clavicle are shown in table 28. In all the groups of primates, except the gorillas, the left clavicle surpasses the right one in length more frequently than *vice versa*. According to Martin (1928) this is the general rule among human races. This result is rather surprising, particularly in regard to man, in view of the fact that it is the right arm which is generally the longer one and that the right half of the human thorax is on an average wider than the left half (Gaupp, 1909).

The discussion so far has dealt merely with the relative frequencies of asymmetries, but it is of importance also to know to what extent the two sides of the body may differ from each other. For this purpose the

absolute difference is expressed in percentage of the smaller of the two measurements. For instance, the maximum asymmetry among normal femora of adult orang-utans amounts to 10 mm., which is 4.3 per cent of the length of the shorter of the two femora; the greatest difference between the lengths of the two clavicles of any orang-utan is 9 mm., or 6.4 per cent of the length of the shorter clavicle. Perfect symmetry is,

TABLE 29

Average Differences (Including Cases of Symmetry) between the Lengths of the Right and Left Limb Bones and Clavicles (Expressed in Percentage of Smaller Measurement) in the Author's Series of Adult Primates Listed in the Tables 26, 27, and 28.

PRIMATE	HUMERUS	RADIUS	FEMUR	TIBIA	CLAVICLE	AVERAGE
Lower primates	0.9	1.2	0.5	0.5	1.9	*1.0*
Gibbon and siamang	0.8	0.8	0.8	1.0	1.9	*1.1*
Orang-utan	0.9	0.7	0.7	0.8	1.6	*0.9*
Chimpanzee	1.1	0.5	0.7	0.9	1.6	*1.0*
Gorilla	0.7	0.6	0.6	0.8	1.5	*0.8*
Man	1.5	1.7	1.1	1.2	2.7	*1.6*
Average	*1.0*	*0.9*	*0.7*	*0.9*	*1.9*	

naturally, indicated by this method by 0. Table 29 contains the averages of these percentage differences (including all cases with 0) between the right and left bones. It is seen at once that in all primates the clavicle is much more asymmetrical than any of the limb bones. The average percentage difference between measurements on the right and on the left amounts to 2.7 in human clavicles and to only 1.1 to 1.7 in the limb bones of man. The same average was obtained as 1.1 for the length of the foot in whites and as 1.3 for the same dimension in Central-American Indians (Schultz, 1926). These data suffice to show that the two clavicles have an unusually marked tendency to differ in length.

The last column in table 29 supports the conclusion that the limb bones and clavicles of man are more asymmetrical than those of other primates, indeed, on an average just twice as much as in the gorilla. This finding that the limb bones vary on the two sides of the body more intensively in man than in other primates agrees with the previous result that the proportions between the lengths of the limb bones are more variable in man than in the apes (table 25).

HAND

In his study on the growth of gorilla the author (1927) has demonstrated that the length of the hand in relation to the length of the arm is practically the same in man and gorilla and in both very much shorter than in the other higher primates. These results, which agree with the findings by Fick (1926), indicate that the hand of adult gorilla is less adapted for arboreal life than the hands of the other apes. This chapter deals with the three main proportions between different parts of the skeleton of the primate hand.

TABLE 30

Average Proportions in the Skeleton of the Hand in the Series of Primates Listed in Table XX. The Last Row of Indices Has Been Calculated by the Author from the Detailed Measurements on 59 Complete Hand Skeletons of Adult Whites Recorded by Fick (1926).

PRIMATE	SPECIMENS	RAY I LENGTH / RAY III LENGTH	PHALANGES III LENGTH / RAY III LENGTH	PHALANGES I LENGTH / RAY I LENGTH
Cebus capucinus	1	58.2	64.2	56.4
Alouatta seniculus	1	52.7	67.8	61.0
Pithecus rhesus	1	46.0	57.8	47.5
Papio hamadryas	1	53.4	51.7	45.2
Pygathrix germaini	1	39.6	59.4	50.0
Hylobatidae	7	44.5	60.4	48.6
Pongo pygmaeus	4	34.6	57.7	47.9
Pan spec.?	2	39.5	58.8	50.6
Gorilla gorilla	9	44.6	57.1	47.9
Gorilla beringei	5	49.8	59.1	50.7
Homo (Negro)	18	62.6	58.9	53.4
Homo (White)	14	64.4	58.8	52.6
Homo (White, after Fick)	59	61.8	59.4	54.0

Four measurements were taken on each hand (the left one, with a few unavoidable exceptions), namely the length of the metacarpus and that of the three phalanges of the middle finger and the length of the metacarpus and that of the two phalanges of the thumb. By adding the length of the metacarpus to the total length of the phalanges of the same digit one obtains the length of the particular ray. The averages of the proportions based upon these measurements are listed in table 30. The length of ray I in percentage of ray III expresses the relative length of the thumb. This index ranges between 40 and 58 in the few lower primates studied. Among the higher primates the orang-utan has the lowest average index, *i. e.*, the relatively shortest thumb. The thumb of chimpanzee is but little longer. The third longest thumb is found in the *Hylobatidae* and in the lowland gorilla with indices of not quite 45. In the mountain gorilla the length of the first ray amounts practically to half that of the third ray. As shown by table XX, this index varies between 42.1 and 46.4 in *Gorilla gorilla* and between 48.0 and 52.0 in *G. beringei*. Since these ranges do not overlap there seems to exist a significant difference between the two gorillas, according to which the mountain gorilla possesses a relatively longer thumb than the West-African gorilla, which itself has a considerably longer thumb than the chimpanzee. It should be emphasized that these data do not refer to the outer free thumb but to the entire length of the skeletal thumb of which only a part belongs to the free digit. The human thumb, finally, is relatively longer than in any other primate listed in table 30.

The length of the phalanges of the middle finger forms more than 60 per cent of the length of the third ray in platyrrhines and less than 60 per cent in lower catarrhines. Among the higher primates this proportion is surprisingly constant, deviating in the averages very little from 59. Thus the relative phalangeal length of the long and slender gibbon hand is 60.4, whereas that of the short and broad human hand is almost the same, *i. e.*, 59.4; in the greatly elongated hand of orang-utan this index averages 57.7 and in the shortened and excessively broad hand of gorilla it amounts to even more (in the East-African species), namely to 59.1. It seems unquestionable that among higher primates the human hand has become shortened and the orang-utan hand, for instance, lengthened. This claim could be supported in various ways, but it suffices to mention here that in man the hand amounts to 37 per cent of the trunk height, whereas in orang-utan it amounts to 63 per cent (Mollison 1911). These data combined with

those in table 30 permit the conclusion that the evolutionary shortening as well as lengthening of the hand has affected the metacarpal portion to practically the same extent as the phalangeal portion, since these portions maintained nearly the same relation to each other regardless of the relative total length of the hand. That entirely different conditions exist in the skeleton of the foot of primates will be shown in the following chapter.

The last column in table 30 shows the proportion between the phalangeal part of the thumb and the entire length of the thumb ray. This index is also comparatively constant among higher primates, the averages ranging only between 48 and 54. As in regard to the middle finger, it can be said of the thumb that neither extreme shortening nor lengthening of this digit has affected the proportion between phalanges and metacarpus to any marked extent. In a series of whites, *e. g.*, ray I amounts to 64 per cent of ray III and the phalanges of the thumb form 52.6 per cent of the entire thumb length. In orang-utan the length of the first ray has become reduced to only 34.6 per cent of the length of ray III, but this shortening affected the metacarpal portion of the thumb almost as much as the phalangeal portion, since the relation between the two differs but very little from the same relation in the other apes and even from that in man with the longest thumb. This finding is unexpected in view of the fact that hereditary brachydactylism of the human thumb is manifested particularly by the shortening of the terminal phalanx (Breitenbecher, 1923) and that in the primates with the most extreme reduction of the thumb (*Ateles* and *Colobus*) the phalanges suffered most, being mere vestiges whereas the metacarpus is still fairly well developed (Schultz, 1924, 1926).

As a broad generalization it may be stated in conclusion that the proportions of the hand skeleton are comparatively uniform and conservative among the higher primates.

FOOT

In a recent paper on "The distinctions of the human hallux" Wood Jones (1929) makes the introductory statement that during the last decade:

> "A great deal of detailed work has been done upon the ontogeny and phylogeny of the human foot with a view to establishing its pithecoid origin, and to-day there seems to be some danger that we may be lulled into thinking that the comparatively recent "transformation of the foot of a gorilla into that of a man" is one of easy and actual accomplishment."

After some brief criticism of two of the contentions found in this detailed work by other authors, Wood Jones concludes with the warning that one should not lose sight of "two very simple facts: (1) the extremely early ontogenetic human acquirement of definitely human pedal characters and (2) the vast difference in kind between the best human big toe movements and those habitual in the Anthropoid apes." The second claim will be discussed at the end of this chapter. In regard to the first assertion it should be merely pointed out here that,

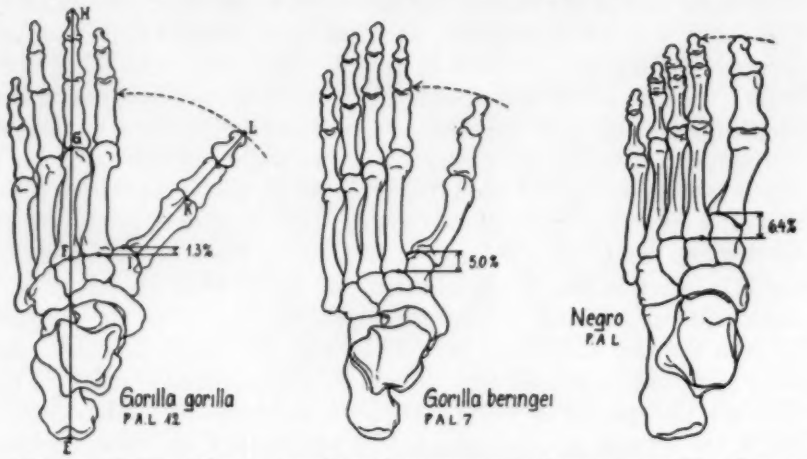


FIG. 20. DORSAL VIEW OF THE FOOT SKELETONS OF A GORILLA GORILLA, A GORILLA BERINGEI, AND A NEGRO, ALL REDUCED TO THE SAME TOTAL FOOT LENGTH (DRAWN WITH DIOPTROGRAPH FROM LIGAMENTOUS PREPARATIONS). The letters in the drawing on the left are explained in the discussion of the measuring technique.

in view of the known facts, it constitutes an untenable statement. Lazarus (1896), Volkov (1903/04), Straus (1927), and the author 1923, 1924, 1925, and 1926) have clearly demonstrated very marked and significant ontogenetic changes in the skeleton and in the outer form of the human foot. It has been shown, for instance, that the human embryo possesses a very short tarsus, relatively long phalanges, and a divergent and proportionately short great toe, and that the middle toe can be the longest of the digits in early stages of human development. None of these embryonic conditions could possibly be interpreted as "definitely human characters," not only because they differ very much from the adult conditions of the human foot but also because they are strikingly similar to the embryonic characters of the feet of other primates (see *e. g.* Schultz, 1924; Growth Studies on Primates, fig. 9).

Before the new data appertaining to the skeleton of the foot of man and apes can be discussed, it is necessary to state briefly the methods by which these data were obtained. Figure 20 shows the measurements in semi-diagrammatic form. All measurements were taken on (wherever possible left) foot skeletons in which the tarsus had not yet been disarticulated.

1. Tarsus length = greatest distance between *tuber calcanei* and middle of joint on *cuneiforme* III for *metatarsale* III (*E* - *F*).
2. Metatarsus III length = greatest length of the middle metatarsal bone from the center of the proximal joint surface (*F* - *G*).
3. Basal phalanx III length; 4. Middle phalanx III length; 5. Terminal phalanx III length = greatest lengths through central axis of bones.
6. Phalanges III length = sum of measurements Nos. 3, 4, and 5 (*G* - *H*).
7. Ray III length = sum of measurements Nos. 2 and 6 (*F* - *H*).
8. Total foot length = sum of measurements Nos. 1 and 7 (*E* - *H*).
9. Metatarsus I length = greatest length through central axis of the first metatarsal bone (*I* - *K*).
10. Phalanges I lengths = greatest length of the two hallucial phalanges through central axis (*K* - *L*).
11. Ray I length = sum of measurements 9 and 10 (*I* - *L*).

TABLE 31

Average Proportions of the Skeleton of the Foot of the Primates Listed in Table XXI and of a Negro Fetus of the 10th Week

PRIMATE	SPECIMENS	TARSUS LENGTH / TOTAL FOOT LENGTH	METATARSUS III L. / TOTAL FOOT LENGTH	PHALANGES III L. / TOTAL FOOT LENGTH	RAY I LENGTH / RAY III LENGTH	PHALANGES I L. / METATARSUS I L.
Cebus capucinus	1	32.3	30.7	37.0	66.2	90.0
Alouatta seniculus	1	29.2	30.3	40.5	56.3	91.4
Pithecus rhesus	1	32.0	32.8	35.2	51.7	73.1
Pygathrix germaini	1	29.2	30.5	40.3	52.6	72.2
Hylobatidae	10	28.2	30.6	41.2	67.3	83.2
Pongo pygmaeus	5	26.1	30.6	43.3	35.5	81.5
Pan spec.?	2	35.3	29.0	35.7	66.5	93.6
Gorilla gorilla	9	39.5	27.6	32.9	64.8	88.7
Gorilla beringei	6	40.7	26.4	32.9	72.9	93.1
Homo (Negro & White)	10	49.2	29.6	21.2	97.2	93.1
Homo (fetus, 10th w.)	1	37.0	30.0	33.0	73.0	....

The proportions between these measurements are given in tables XXI, 31, 32, and 33. The first three indices in table 31 show the percentage participation of the three main portions of the foot skeleton in the composition of the total length of the foot. The middle portion, or metatarsus III, is much more uniform among primates than the proximal and distal portions, constituting in general approximately 30 per cent of the foot length. The latter percentage also remains practically unchanged during growth (Straus, 1927 and table 31). The relative length of the tarsus varies in the proximity of 30 among the lower primates. The gibbons, siamangs, and most of all the orang-utan are characterized by a tarsus proportionately even shorter than in most monkeys. The relative tarsus length of chimpanzee is larger than in the previously mentioned primates but considerably shorter than in gorilla. The latter approaches man, who has the longest tarsus among all primates, namely one which forms nearly half of the total foot length. This extreme length of the human tarsus develops only gradually in the course of growth. Small human fetuses still possess a relative tarsus length of only 37, a value which stands very much closer to that of adult chimpanzee (35.3) than to that of adult man (49.2) (see also Straus, 1927, table 20). The same is true in regard to the relative length of the phalanges, which amounts to 35.7 in chimpanzee, to 33.0 in the human fetus, and to only 21.2 in adult man. The last percentage represents the minimum of all primates, *i. e.*, man has extremely short phalanges as compared with apes and monkeys but proportionately still very much longer ones in early stages of human development.

The fourth index in table 31 shows the relation in length between the first and the third ray. The extremes of this proportion are found in orang-utan and in man, the former having the relatively shortest, the latter the relatively longest hallux. Again it can be demonstrated that the human distinction is not yet present in early stages of growth. This index amounting to only 73 in a human fetus of the 10th week (see also Straus, 1927, table 24), a value which equals that in adult *Gorilla beringei* (72.9). In adult man this index can rise to as much as 108.1. It is interesting to find in table XXI that the ranges of variation in this proportion do not overlap in the two gorilla species and that, consequently, the average for the mountain gorilla is considerably larger than that for the lowland gorilla. This alone causes the great toe to reach farther distally in the former than in the latter, but it becomes accentuated by the fact that the *cuneiforme* I

also extends farther distally in *Gorilla beringei* than in *Gorilla gorilla*. If the projective distance between the most distal points on the cuneiform bones I and II is expressed in percentage of the total foot length, this distance is found to be relatively much greater in the mountain gorilla (5.0%) and man (6.4%) than in the lowland gorilla (1.3%) or in the chimpanzee (1–2%). This difference is seen at once in the exact drawings of figure 20.

From the data in the last column of table 31, the proportions between the length of the phalanges and that of the metatarsus of the hallux is seen to be the same in man, mountain gorilla, and chimpanzee. This finding is significant, because it proves that the unusual length of the great toe in man can not be due to an extraordinary length of either the metatarsus or the phalanges. Schwalbe (1916) has already shown that the proportion in length between the first and the second metatarsus is very similar in man and chimpanzee. This leaves only the length of the phalanges of the lateral toes to account for the marked difference between man and apes in regard to the relative length of

TABLE 32

Averages of the Lengths of Metatarsus III, Phalanges III, and Ray I Expressed in Percentage of the Length of the Tarsus in the Higher Primates Listed in Table XXI and in the Same Negro Fetus as Used in Table 31

PRIMATE	SPECIMENS	METATARSUS III L.	PHALANGES III L.	RAY I L.
		IN PERCENTAGE OF TARSUS LENGTH		
Pongo pygmaeus	5	117.2	165.6	100.2
Pan spec.?	2	82.3	100.7	122.0
Gorilla gorilla	9	70.0	83.5	99.4
Gorilla beringei	6	65.3	81.3	106.6
Homo (Negro & White)	10	60.3	43.1	100.3
Homo (fetus, 10th w.)	1	81.0	89.0	124.0

the hallux. In table 31 the length of the phalanges of the middle toe was compared with the total foot length and this proportion was found to be much smaller in man than in the apes and smaller in adults than in fetuses of man. Table 32 shows the proportion between the length of the phalanges III and the length of the tarsus. This index is also very much lower in adult man than in the apes and decreases in man ontogenetically from 89 to 43. The value in the human fetus

is even higher than that in the adult gorilla. It is also especially noteworthy that in regard to this proportion man is approached more closely by the gorilla than by the other large apes.

When the length of the hallux is compared, not with the length of one of the other digits, as in table 31, but with the length of the tarsus, as in table 32, it is found that man does not differ essentially from the anthropoid apes in regard to the length of his great toe.

These data suffice to support the conclusion that the great toe has not become lengthened in the course of man's evolution but that the phalangeal portions of the lateral toes of man have become

FIG. 21. LEFT FIGURE: THE PHALANGES II TO V OF THE YOUNG FEMALE MOUNTAIN GORILLA "CONGO" IN THEIR NATURAL POSITION WITHIN THE FOOT (SHOWN BY OUTLINES), RECONSTRUCTED FROM DETAILED AND CAREFUL MEASUREMENTS ON THE FRESH AND ONLY PARTLY SKINNED FOOT. MIDDLE FIGURE: PLANTAR VIEW OF THE LATERAL DIGITS AND DISTAL PORTION OF THE SOLE OF THE SAME GORILLA FOOT. When the specimen was received the skin had been turned inside out, like a glove, as far as the cut shown in the figure. RIGHT FIGURE: DORSAL VIEW OF THE SAME PORTION OF THE FOOT AS SHOWN IN THE MIDDLE FIGURE.

very much shortened phylogenetically as they decrease in relative length during human ontogeny. Thus the writer agrees completely with the statements by Schwalbe (1916), Virchow (1917), Weidenreich (1921), and others that the foot skeleton of man differs from that of anthropoid apes chiefly in regard to the length of the phalangeal portions of the second to fifth toes and comparatively little in regard to the first toe. It should also be pointed out here that, according to the various indices, the shortening of the lateral digits in man, as compared with gorilla, is no greater than the lengthening of these digits in orang-utan, as compared with gorilla. The latter lengthening

represents undoubtedly an adaptation to the extreme arboreal life of orang-utan, just as the former shortening must have occurred in response to the extreme terrestrial life of man which removed the need for long grasping toes. The latter need persists in adult gorilla, although he has become largely a terrestial animal. The foot of the mountain gorilla retained fairly long phalanges but they are tied together by the soft parts so that the lateral digits can be flexed only as a unit. This is clearly shown in figure 21 on the example of a young female *Gorilla beringei*. In this specimen the toes II, III, and IV are joined by webs which extend beyond the base of the nails, a degree of webbing which far surpasses that of other primates. What amounts to the sole of the foot reaches all the way to the distal ends of the middle phalanges, leaving the metatarso-phalangeal joints far proximally to this distal end of the *planta*. In these conditions, which are somewhat more extreme in the specimen of figure 21 than in three other mountain gorillas seen by the author,[6] *Gorilla beringei* differs markedly from the chimpanzee and orang-utan, in which the sole reaches not farther than the middle of the basal phalanges and in which the toes are not united by webbing. The mountain gorilla differs even from the lowland gorilla, inasmuch as the sole of the latter extends only to the distal end of the basal phalanges or, occasionally, not quite so far. From these notes it is seen that in one ape, the mountain gorilla, the outer toes II to V are proportionately as short as in man, and even more closely united, but the skeletal toes of even this ape are very much longer than in man, which means that the digits and sole can be flexed much more effectively in the former than in the latter.

It remains to answer the question whether the extreme phylogenetic shortening of the lateral toes in man affected the three types of phalanges in the same or in differing degrees. The comparative data in table 33 provide the solution of this problem. The relative length of the basal phalanx is fairly constant in all primates and the value for man lies within the range of the average values for the large apes. The relative length of the terminal phalanx is practically the same in man and mountain gorilla; this phalanx could hardly have been expected to bear the brunt of the shortening process since it supports the nail of the toe. The relative length of the middle phalanx, however, is much shorter in man than in any other primate, a fact which is strikingly

[6] A photograph of the feet of an older fetus of *Gorilla beringei*, kindly sent to the writer by Prof. I. Broman, shows that in this specimen the lateral toes are as much united as in the author's gorilla P. A. L. 7.

TABLE 33

The Length of the Phalanges of the Middle Toe in Percentage of the Total Length of These Phalanges in the Primates Listed in Table XXI

PRIMATE	SPECIMENS	BASAL	MIDDLE	TERMINAL
		Phalanx III in percentage of total length of all phalanges III		
Cebus capucinus	1	46.8	31.9	21.3
Alouatta seniculus	1	51.5	30.9	17.6
Pithecus rhesus	1	51.1	31.1	17.8
Pygathrix germaini	1	47.0	33.3	19.7
Lasiopyga pygerythra	1	51.0	33.3	15.7
Colobus abyssinicus	1	49.2	33.3	17.5
Hylobatidae	10	50.4	32.5	17.1
Pongo pygmaeus	5	53.1	32.2	14.6
Pan spec.?	2	52.3	29.9	17.8
Gorilla gorilla	9	49.1	31.0	19.9
Gorilla beringei	6	49.1	27.8	23.0
Homo (Negro & White)	10	52.8	23.9	23.3

illustrated by the examples in figure 20. It can be stated, therefore, that the evolutionary reduction in length of the lateral digits of man affected the middle phalanges more than the basal or terminal phalanges. This is most likely connected with the fact that in man the middle phalanges are very frequently mere vestiges and fused with the terminal phalanges. Such fusions are very common in the fifth toe (80 per cent of Japanese), but occur in all the toes II to V and even in fetal stages of growth (for further details see *e. g.* Wiedersheim, 1908, and Martin, 1928). No such fusion was found by the author in any of the numerous foot skeletons of monkeys and apes examined by him, nor could he discover in the literature any report on such an occurrence in a primate besides man. Attention should also here be called to a fact which may be of some particular significance in this connection, namely that hereditary brachyphalangy in the human foot affects usually the middle phalanges. This was the case, for instance, in the Norwegian family (including 6 generations) studied by Mohr and Wriedt (1919). After a thorough review of the literature these authors conclude that: "In hereditary cases of brachyphalangy, as well as in brachyphalangy due

to embryological disturbances, the second row of phalanges seems to be most often and most severely affected."

The last part of this chapter contributes some facts toward the solution of the important problem of man's joint between the hallux and the first cuneiform bone, a problem which has been more frequently discussed than investigated. Ever since Leboucq (1882) claimed that even in the human embryo this joint is perfectly flat and not convex as in other primates, his statement has been fully quoted or belittled in the many arguments for or against the theory that the great toe of man evolved from an opposable and abduced type of toe. Miller (1920), for instance, concludes from the paper by Lebouceq that "the fact that the basal joint of the human hallux appears to be free from gorilloid taint at every stage of its development is one whose possible phylogenetic significance cannot be ignored." On the other hand, Morton (1922), for instance, states that "in the absence of any means of determining accurately the proper interpretation of the embryological picture, the findings of Leboucq have no value in disproving the possibility of derivation of the human cuneiform from one of gorilloid type." The following comment by Hooton (1930) may be the simplest solution of this controversy: "the absence in the human foetus of a convex cuneiform joint for the first metatarsal does not trouble me in the least. Recapitulation is a coarse-meshed sieve, which retains only a few obvious ancestral features."

The facts reported in the literature concerning this joint are collected in the following notes. In monkeys and apes the joint surface on the first cuneiform bone is convex and the corresponding joint surface on the base of the hallux is concave, thus permitting the movements of the great toe to and from the second toe (see fig. 22, drawing on the left). In man these joint surfaces are commonly assumed to be entirely flat, preventing thereby any movement of the first metatarsal. According to Leboucq (1822) they are already flat in human embryos 21 mm. long (according to the writer's experience there are many technical difficulties as well as uncertainties in the determination of the exact shape of the minute and comparatively soft joint of such a small specimen). Straus (1927), who investigated the foot skeletons of a considerable number of human fetuses, reports that: "In the youngest stages this joint surface is, as a rule, not saddle-shaped as in adult great apes, but is quite like the adult human, being *nearly* flat." " . . . the author has observed several later human fetuses possessing a definite simian rounding of the distal joint surface of the entocuneiform.

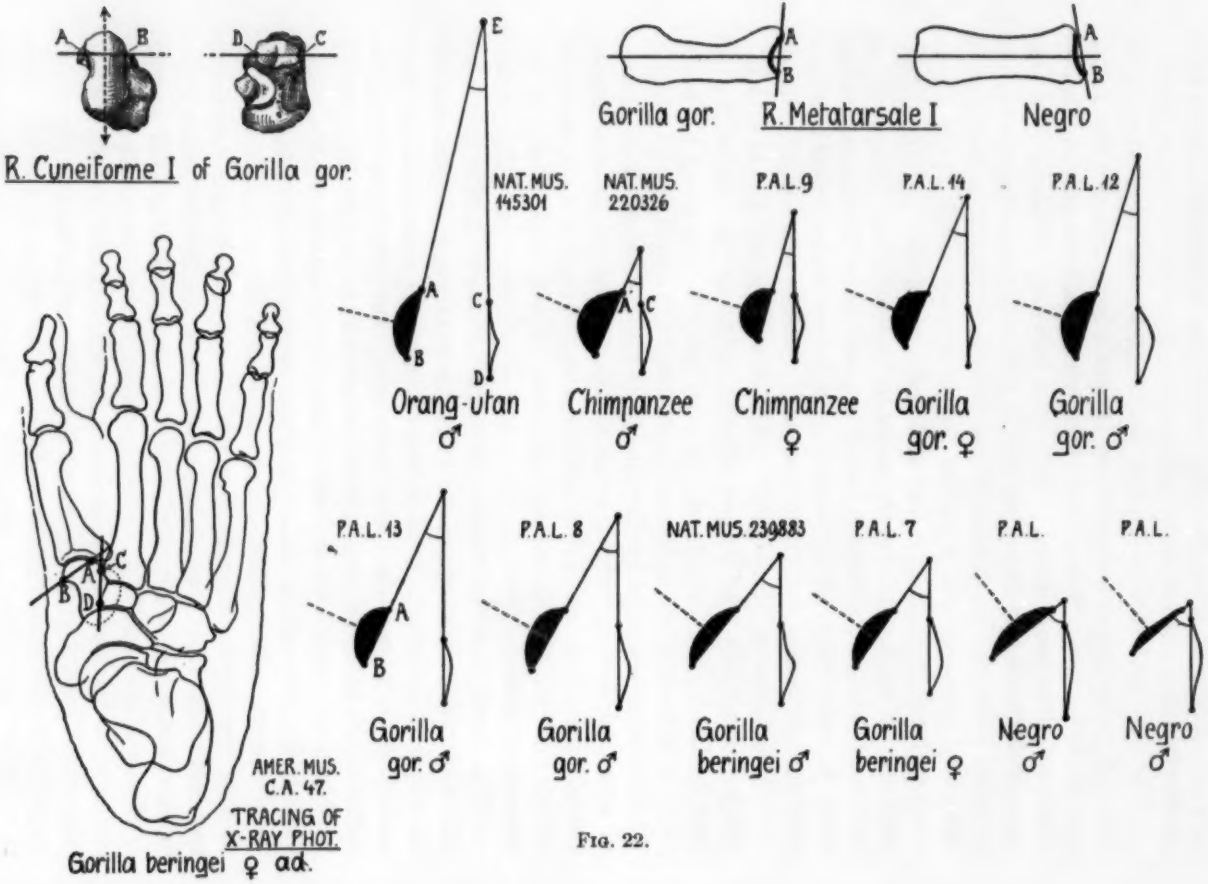

A
B
D
C
R. Cuneiforme I of Gorilla gor.
AMER. MUS. C.A. 47.
TRACING OF X-RAY PHOT.
Gorilla beringei ♀ ad.
E
NAT. MUS. 145301
NAT. MUS. 220326
P.A.L. 9
P.A.L. 14
P.A.L. 12
Orang-utan ♂
Chimpanzee ♂
Chimpanzee ♀
Gorilla gor. ♀
Gorilla gor. ♂
Gorilla gor.
R. Metatarsale I
Negro
P.A.L. 13
P.A.L. 8
NAT. MUS. 239883
P.A.L. 7
P.A.L.
P.A.L.
Gorilla gor. ♂
Gorilla gor. ♂
Gorilla beringei ♂
Gorilla beringei ♀
Negro ♂
Negro ♂

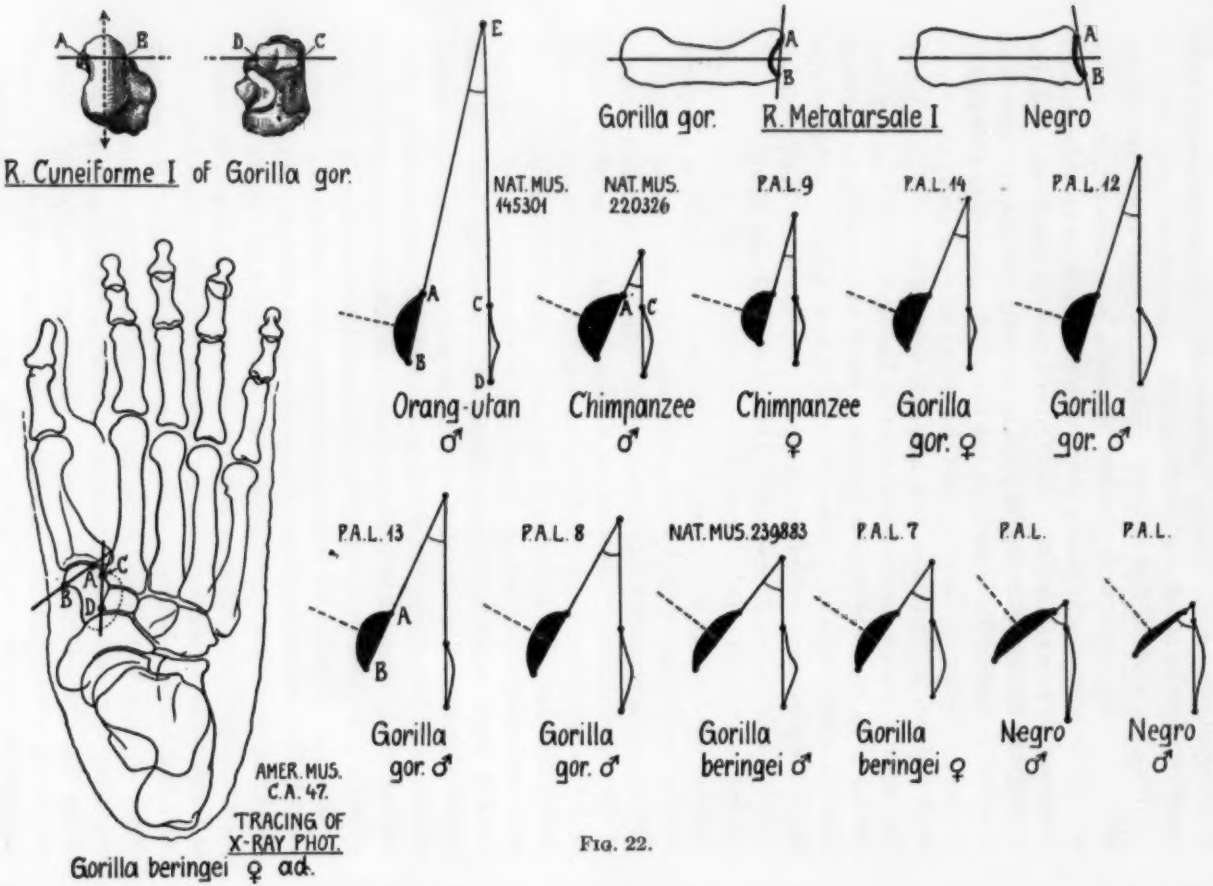
FIG. 22.

One entocuneiform of a fetus of the seventh month exhibited a saddle-shaped facet for metatarsus I. To all appearances, therefore, this condition can, although only occasionally, appear in man." There exist several reports that in adult man this joint on the first cuneiform bone is not always flat but can be quite convex in a transverse direction. Lucae (1864–65) found the radius for the curve of this convexity to be 36 mm. long in the white and 27 mm. in the Japanese. According to Aeby (1878) this same radius varies even only between 12.5 and 27 mm. in adult whites and amounts to 8 mm. in an adult lowland gorilla. Supported by these data Aeby states emphatically that the distal joint surface on the first cuneiform bone of man is always convex and, therefore, does not differ fundamentally from the same condition in apes. Virchow (1919) mentions this convexity in his careful description of the feet of various colored races and measured the depth of the corresponding concavity in the proximal joint of the first metatarsal bone. This depth varied between 1.3 and 4.0 mm. and was in several human feet greater than in some anthropoid apes, among which it ranges according to the same author between 2.8 and 5.0 mm.

The most important link missing in the chain of evidence provided by these data is accurate information in regard to the degrees of convexity of this joint in the different apes. To supply such data the author has carefully drawn and measured the joint on the cuneiform bones of a series of higher primates. As shown by figure 22, the representative section (*A* - *B*) of the joint for the hallux was drawn perpendicular to the longitudinal axis of the joint, *i. e.*, roughly parallel to the plantar surface of the foot, and always opposite the middle of the joint which the first cuneiform bone forms with the second one, as well as with the second metatarsal bone. The terminal points (*C* and *D*) of the latter joint were also marked on the section to determine thereby a guide line which was found to have always practically the same direction as the morphological axis of the foot. It seemed desirable to study not only the curvature of the joint for the hallux but also the direction of this joint, because the amount of abduction of the great toe is dependent as much upon the direction as upon the convexity of

FIG. 22. TRACING OF THE X-RAY PHOTOGRAPH OF THE SKINNED FOOT OF AN ADULT FEMALE MOUNTAIN GORILLA, SHOWING THE LOCATION OF THE SECTION THROUGH THE JOINT FOR THE HALLUX ON THE CUNEIFORME I. The enlarged figures of the first cuneiform bone in the upper left corner show the exact position of the sections which were drawn with Martin's diagraph. The figures on the right are accurate copies of these sections through the first cuneiform bones of various higher primates. The two drawings at the top of this figure are longitudinal sections through the first metatarsal bones of gorilla and man, drawn also with the diagraph and this in the plane determined by the points *A* and *B*.

FIG. 22.
X-RAY PHOT.
Gorilla beringei ♀ ad.


A
B
D
C
R. Cuneiforme I of Gorilla gor.
Gorilla gor.
R. Metatarsale I
Negro
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NAT. MUS. 145301
NAT. MUS. 220326
P.A.L. 9
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Orang-utan ♂
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Gorilla gor. ♀
Gorilla gor. ♂
P.A.L. 13
P.A.L. 8
NAT. MUS. 239883
P.A.L. 7
P.A.L.
P.A.L.
Gorilla gor. ♂
Gorilla gor. ♂
Gorilla beringei ♂
Gorilla beringei ♀
Negro ♂
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AMER. MUS. C.A. 47.
TRACING OF X-RAY PHOT.
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FIG. 22.

One entocuneiform of a fetus of the seventh month exhibited a saddle-shaped facet for metatarsus I. To all appearances, therefore, this condition can, although only occasionally, appear in man." There exist several reports that in adult man this joint on the first cuneiform bone is not always flat but can be quite convex in a transverse direction. Lucae (1864–65) found the radius for the curve of this convexity to be 36 mm. long in the white and 27 mm. in the Japanese. According to Aeby (1878) this same radius varies even only between 12.5 and 27 mm. in adult whites and amounts to 8 mm. in an adult lowland gorilla. Supported by these data Aeby states emphatically that the distal joint surface on the first cuneiform bone of man is always convex and, therefore, does not differ fundamentally from the same condition in apes. Virchow (1919) mentions this convexity in his careful description of the feet of various colored races and measured the depth of the corresponding concavity in the proximal joint of the first metatarsal bone. This depth varied between 1.3 and 4.0 mm. and was in several human feet greater than in some anthropoid apes, among which it ranges according to the same author between 2.8 and 5.0 mm.

The most important link missing in the chain of evidence provided by these data is accurate information in regard to the degrees of convexity of this joint in the different apes. To supply such data the author has carefully drawn and measured the joint on the cuneiform bones of a series of higher primates. As shown by figure 22, the representative section (*A* - *B*) of the joint for the hallux was drawn perpendicular to the longitudinal axis of the joint, *i. e.*, roughly parallel to the plantar surface of the foot, and always opposite the middle of the joint which the first cuneiform bone forms with the second one, as well as with the second metatarsal bone. The terminal points (*C* and *D*) of the latter joint were also marked on the section to determine thereby a guide line which was found to have always practically the same direction as the morphological axis of the foot. It seemed desirable to study not only the curvature of the joint for the hallux but also the direction of this joint, because the amount of abduction of the great toe is dependent as much upon the direction as upon the convexity of

FIG. 22. TRACING OF THE X-RAY PHOTOGRAPH OF THE SKINNED FOOT OF AN ADULT FEMALE MOUNTAIN GORILLA, SHOWING THE LOCATION OF THE SECTION THROUGH THE JOINT FOR THE HALLUX ON THE CUNEIFORME I. The enlarged figures of the first cuneiform bone in the upper left corner show the exact position of the sections which were drawn with Martin's diagraph. The figures on the right are accurate copies of these sections through the first cuneiform bones of various higher primates. The two drawings at the top of this figure are longitudinal sections through the first metatarsal bones of gorilla and man, drawn also with the diagraph and this in the plane determined by the points *A* and *B*.

FIG. 22.

X-RAY PHOT.

Gorilla beringei ♀ ad.

the joint. This direction was measured (on the drawing) by the angle (*B* - *E* - *D*) between the distal prolongation of the base of the joint curvature (*A* - *B*) and the morphological foot axis, as determined by the points *C* and *D*. The actual shape and direction of the joint in a number of higher primates is shown in figure 22 and the measured values for these conditions are listed in table 34. The degree of con-

TABLE 34

The Curvature and the Direction of the Joint Surface (for the Hallux) on the First Cuneiform Bone in Some Adult Higher Primates

PRIMATE	COLLECTION	RELATIVE HEIGHT OF JOINT CURVATURE	ANGLE B - E - D (DEGREES)
Pongo pygmaeus	Nat. M. 145301	29.6	13
Pan spec.?	P. A. L. 9	50.0	15
Pan spec.?	Nat. M. 220326	44.4	24
Gorilla gorilla	P. A. L. 14	41.6	21
Gorilla gorilla	P. A. L. 12	37.0	18
Gorilla gorilla	P. A. L. 13	36.0	24
Gorilla gorilla	P. A. L. 8	30.4	30
Gorilla beringei	P. A. L. 7	21.4	35
Gorilla beringei	Nat. M. 239883	21.4	39
Homo (Negro)	P. A. L.	17.7	51
Homo (Negro)	P. A. L.	15.3	56
Homo (Negro)	P. A. L.	11.1	50

vexity is expressed by the percentage relation between the greatest height of the joint curve and the length of the curve base (*A* − *B*). In the orang-utan the joint is not very convex, but it is directed nearly parallel to the foot axis, which indicates that the great toe of this ape can be abduced and adduced only within comparatively narrow limits, and that it points most commonly perpendicularly away from the second toe. All this is in perfect agreement with the well-known rudimentary nature of the hallux in orang-utan. In chimpanzee the joint is directed slightly more forward than in orang-utan and it is very much more convex than in the latter or in any other higher primate. Indeed, in one of the two cases studied the curve forms a complete semicircle (relative height = 50). In the lowland gorilla the joint is less convex than in chimpanzee and the angle representing its direction is larger. In the two specimens of *Gorilla beringei* listed in table 34, the

degree of convexity approaches that in some human beings more closely than that in *Gorilla gorilla*, a fact seen also in figure 22. The joint is furthermore directed more forward and less sidewise in the mountain gorilla than in the other apes. In the first three foot skeletons of adult male negroes, picked at random from a box containing many more, the relative height of the joint curvature ranges from 11.1 to 17.7, *i. e.*, very close to the value of 21.4 in the mountain gorilla. The angle between the joint base and the foot axis varies in these human skeletons between 50° and 56°. This is very significant not only because the minimum in man (50°) differs less from the maximum (39°) in an ape than the latter differs from the minimum (13°) in another ape, but also because even 56° in man is far from an angle of 90°, which would represent the mechanically ideal direction for this joint in man. Since the first and second metatarsi of man are practically parallel to each other, and since the tarsal joint for the latter stands perpendicular to the foot axis, one should expect the tarsal joint of the former to have a similar direction. Instead, it is found to point almost as much to the side as forward. This particular direction of the tarsal joint surface would cause the human hallux to maintain a position of marked abduction were it not for the fact that a compensation has taken place in the basal joint of the first metatarsal which has become bent in a direction opposite to that in apes (see fig. 22, longitudinal sections of first metatarsals).

These data amply support the conclusion that the exact formation of the joint between the hallux and the first cuneiform bone differs between man and ape only in degree but not in principle. Man differs in this respect least from the mountain gorilla. The fact that in man this joint still points so much to the side and that it can still be considerably curved, is explained only by the assumption that the human great toe was movable and was habitually held abduced in earlier stages of its evolution. The loss of metatarsal movability and the nearly complete adduction of the human great toe have altered the joint at its base relatively little from the condition in a primate foot with a movable hallux, such as in *Gorilla beringei*. What alteration did take place in man was clearly a compromise, dictated by inherited conditions and has not yet resulted in mechanically perfect arrangements.

SUMMARY AND CONCLUSIONS

This study of the skeleton of the trunk and limbs of primates, though incomplete in many respects, permits the generalized conclusion

TABLE 35

*A Generalized Survey of the Average Skeletal Features of Primates, as Found in the Present Study. Since the Conditions in Lower Primates Have Not Been Studied in Detail the First Column of This Table Is Merely Tentative. The Most Primitive Condition Is Marked by #, the Most Highly Specialized Condition by **

	SKELETAL CHARACTER	LOWER PRIMATES	GIBBON AND SIAMANG	ORANG-UTAN	CHIMPANZEE	GORILLA	MAN
SPINAL COLUMN:	Average number of *thoracic* vertebrae	12–15#	12.9	11.9*	13.0	13.0	12.0
	Average number of *lumbar* vertebrae	4–7#	4.9	4.0	3.9	3.6*	5.0
	Average number of *thoracolumbar* vertebrae	18–20#	17.8	16.0*	16.8	16.6	17.0
	Average number of *sacral* vertebrae	3#	4.4	5.1	5.4	5.5*	5.2
	Shape of *sacrum*	broad but short#	broad	broad	broad	very broad	extremely broad*
	Ventral surface of sacrum (in midsagittal plane)	straight#	slightly concave	markedly concave	slightly concave	very concave	extremely concave*
	Average number of *caudal* (coccygeal) vertebrae	generally 8–28#	2.7*	2.8	3.3	3.1	4.2
	Average *total number* of vertebrae	approximately 48#	32.0	30.8*	32.6	32.2	33.0
STERNUM:	*Manubrium*	small narrow#	large very broad*	large broad	large broad	large broad	less broad than in apes
	Corpus	very long# and narrow# segments separate#	very short* and broad corpus and manubrium fuse often	short and very broad* segments fuse very rarely	long and narrow segments fuse frequently	short and broad segments fuse rarely	fairly long and broad segments fused*
CLAVICLE:	Length	usually short#	short	very long*	medium length	medium length	comparatively long
	Thickness	fairly thick	slender	slender	medium thickness	thick	medium thickness
	Curvature	usually curved	single curve	straight	S-shaped	acromial end bent	S-shaped
SCAPULA:	*General shape*	usually narrow	narrow	very broad	narrow for an ape	broad	very broad
	Scapular index	78–143#	110–128	69	83	70–76	63*–66
	Supraspinal fossa	usually very narrow	narrow	very narrow	very broad	quite broad	broad

	Suprascapular index	...17♯–40...	...34–39...	.....29.....	.....53*....	.....51....	.....44 . .
	Infraspinal fossa	narrow to broad	very narrow	extremely broad	not broad	broad	very broad
	Infraspinal index	....53♯–100..	...44–56...	.....116*....	.....68.....	.....85....	111
	Vertebral border	convex♯	convex	convex or straight	convex or straight	frequently concave*	rarely concave
	Acromion	short♯	slightly longer	long	long	very long*	longer than in Chimpanzee
		narrow♯	broad	rather narrow	broad	very broad	extremely broad*
PELVIS:	*Ilium* length	long♯	very long*	long	long	long	very short*
	Total ilium width	narrow♯	broad	broader than in Chimpanzee	broad	very broad	very broad*
	Fossa iliaca	very narrow♯	broad	broad	narrower than in orang-utan	extremely broad*	comparatively narrow
	Transverse curvature of fossa iliaca	convex♯	concave	concave	slightly concave	extremely concave*	very concave
	Sacral surface	comparatively small, long and narrow as compared with man					very large* and broad
LONG BONES OF LIMBS:	$\frac{\text{Radius}}{\text{Humerus}} \times 100$	..about 100♯.	....112*...	.....101.....	.....93.....	...76–85...	.....75*
	$\frac{\text{Tibia}}{\text{Femur}} \times 100$	..about 93♯..	.....87....	.....92.....	.....84.....	..78*–81...	85
	$\frac{\text{Humerus + Radius}}{\text{Femur + Tibia}} \times 100$	generally 68–89♯	...128–148*.	.....144.....	.....108.....	..112–117..	secondarily 70*
	$\frac{\text{Humerus + Radius}}{\text{Trunk height}} \times 100$	.....	...174–208*.	.....154.....	.....120.....	....115....	...110–128
	$\frac{\text{Femur + Tibia}}{\text{Trunk height}} \times 100$	.....	.....144...	.....109.....	.....108.....	....101....	..173–197*
HAND:	Relative *total length*	....short♯....	....long....	..very long*..	.....long.....	...short...	....short
	$\frac{\text{Ray I (}\textit{thumb}\text{)}}{\text{Ray III}} \times 100$	...40–58♯....	....44.....	.....35*.....	.....40.....	...45–50...	63
FOOT:	$\frac{\text{Tarsus length}}{\text{Foot length}} \times 100$	.....30♯....	.....28.....	.....26.....	.....35.....	.....40.....	.....49*
	$\frac{\text{Phalanges III l.}}{\text{Foot length}} \times 100$	...35♯–40....	.....41.....	.....43*.....	.....36.....	.....33.....	.....21*
	Hallux	long♯	long	very short*	long	long	long
	Tarsal joint for hallux	convex♯	convex	not very convex	very convex	convex to slightly convex	slightly convex*

that in regard to these structures the higher primates as a group are clearly separated from the other and decidedly more primitive primates. The *Hylobatidae* occupy in many features an intermediate position, but in general they are much more closely allied with the anthropoid apes than with the other catarrhines. As far as these skeletal structures are concerned, there can also be no doubt that the three large apes represent one natural group, standing approximately midway between the gibbons and man. Within this group the two African apes resemble each other more closely than either resembles the orang-utan.

Table 35 gives a systematic and very condensed survey of the more important results of this paper. A study of this table reveals the fact that each higher primate has some skeletal features which are more highly specialized than in any other primate, but there exists not one primate of which it can be said that its entire skeleton is *the* most specialized one. By counting the number of asterisks in the various columns of table 35, it is found that the gibbon and siamang possess 7 features which have evolved to a greater extreme than in any other primate, that orang-utan possesses 10, chimpanzee only 1, gorilla 7, and man 14. This means, for instance, that 14 skeletal characters are farther removed from the common ancestral condition in man than in apes, but in 23 other characters one or another ape has become more highly specialized than man. Naturally, these figures can convey only an approximate idea of the general relative degrees of specialization in the various primates and do not show the direction of such specialization. In many instances these evolutionary differentiations have proceeded in opposite directions in various types of primates, so that two quite different forms may be equally far removed from the original ancestral condition. A clear example of this exists in the phalanges of the second to fifth toes, which have become greatly lengthened in orang-utan and extremely shortened in man.

As shown most conveniently by table 35, man's skeletal peculiarities exist chiefly in the pelvis (including the unique position of the pelvis), in the proportions of the long bones of the lower extremity, and in the foot. Most of the conditions studied in the spine, the sternum, the shoulder girdle, and the upper extremity have evolved into greater extremes in one or another of the apes than in man. The outstanding characteristics of orang-utan are the unparalleled reductions in the number of vertebrae and in the lengths of the first digits of hand and foot. The *Hylobatidae* surpass all other primates especially in regard to

the extreme shortening of the coccyx and of the *corpus sterni*, and in regard to the extreme lengthening of the upper limb, particularly the forearm. The greatest gap between the *Hylobatidae* and the lower primates exists in the conditions of the spinal column, the sternum, the pelvis, and the long bones of the upper limb, all of which are much more

TABLE 36

*Average Condition of Skeletal Characters Differing in Hylobates and Symphalangus Syndactylus and the Relative Position of Symphalangus Klossi (Only Two Specimens) According to the Same Characters. The Most Highly Specialized Condition Is Marked with *.*

DISTINGUISHING SKELETAL CHARACTER		HYLOBATES	SYMPHALANGUS KLOSSI	SYMPHALANGUS SYNDACTYLUS
Average number of lumbar vertebrae		5.0	5.5	4.7*
Average number of thoracolumbar verteb.		17.9	18.5	17.6*
Average total number of vertebrae		31.9	35.0	31.6*
Sternum:	$\frac{\text{Manubrium length}}{\text{Corpus length}} \times 100$	52	60	82*
	$\frac{\text{Manubrium breadth}}{\text{Manubrium length}} \times 100$	154*	150	135
	$\frac{\text{Corpus breadth}}{\text{Corpus length}} \times 100$	39	44	53*
Scapula:	Scapular index	128	110*	117
Pelvis:	$\frac{\text{Ilium length}}{\text{Ischium length}} \times 100$	231	222	252*
	$\frac{\text{Pubis length}}{\text{Ischium length}} \times 100$	95	95	112*
	$\frac{\text{Ilium breadth}}{\text{Ilium length}} \times 100$	51	60	62*
	$\frac{\text{Ilium breadth}}{\text{Ischium length}} \times 100$	118	126	156*
Limb bones:	$\frac{\text{Radius length}}{\text{Humerus length}} \times 100$	113	114*	111
	$\frac{\text{Tibia length}}{\text{Femur length}} \times 100$	89	89	86*
	$\frac{\text{Humerus + Radius length}}{\text{Femur + Tibia length}} \times 100$	128	126	148*
	$\frac{\text{Humerus + Radius length}}{\text{Trunk height}} \times 100$	177	183	208*
Comparative size of absolute measurements:		medium	small	large*

highly developed in the former than in the latter. At a number of places in this paper it has been pointed out that a much greater difference exists between the large siamang and any species of *Hylobates* than between any two of the latter. The characters showing such differences are collected in table 36, which also contains the conditions in the small siamang. This long list of features of the skeleton of trunk and limbs alone, including many items in which the two ranges of variations do not overlap, fully justifies the generic rather than specific separation between the large siamang and the gibbons. In 13 characters the former is more highly specialized than the latter and in only one other character exists the reversed relation. There can be no doubt that *Symphalangus syndactylus* approaches the anthropoid apes, particularly the orang-utan, more closely than do the various species of *Hylobates*. The data in table 36 show that *Symphalangus klossi* stands in general decidedly nearer to the gibbons than to the large species of its own genus. For this reason it seems quite likely that *S. klossi* should really either be moved into the genus *Hylobates*, or else should constitute a new genus of its own. Since the author was able to examine only two skeletons of *S. klossi* (besides a few immature, preserved specimens) he can not insist on this proposed change in nomenclature.

In a very careful study on extensive material Coolidge (1929) has shown that there exists a greater difference between the cranial features of the East- and the West-African gorillas than between those of any two local groups of the latter gorillas. In table 37 are listed those features of the skeleton, except the skull, which differ in these two types of gorilla and this to a greater extent than in any two races of lowland gorillas. This list contains a number of characters which distinguish the two types of gorilla in all the specimens studied without any individual exceptions. These differences between the gorillas are frequently as great as, and several times even greater than, the differences between one of the forms of *Gorilla* and the genus *Pan*. For this reason the author can not fully agree with Coolidge, who considered the cranial differences as having merely subspecific significance and proposed to divide the genus *Gorilla* into only two subspecies: *Gorilla gorilla gorilla* and *Gorilla gorilla beringei*. Since so many skeletal differences between the two types of gorilla can be as large as the differences between the two genera of the African apes, the author feels fully justified in giving the mountain gorilla and the lowland gorilla the rank of separate species. It may be added here that of the two, the moun-

TABLE 37

Tentative List of Skeletal Characters Differing in Gorilla Gorilla and Gorilla Beringei. The Conditions of the Same Characters in Chimpanzee Are Added in Order to Provide an Approximate Scale for the Evaluation of the Differences between the Two Gorilla Species.

DISTINGUISHING SKELETAL CHARACTER	GORILLA GORILLA	GORILLA BERINGEI	CHIMPANZEE
Average number of thoracic vertebrae	13.0	12.6	13.0
Average number of lumbar vertebrae	3.6	3.4	3.9
Average number of thoracolumbar vertebrae	16.6	16.0	16.8
Average number of sacral vertebrae	5.5	5.7	5.4
Average total number of vertebrae	32.3	31.7	32.6
$\frac{\text{Clavicle length}}{\text{Humerus length}} \times 100$	37.1 (32.7–39.0)	43.3 (42.0–44.1)	42.7 (36.3–48.3)
Vertebral border of *scapula*	regular	irregular	regular
Length of *ilium:* average	216 mm.	239 mm.	174 mm.
range of variations ♀	191–204 mm.	220–231 mm.	
♂	216–238 mm.	260–268 mm.	
$\frac{\text{Ilium length}}{\text{Ischium length}} \times 100$	186	196	199
$\frac{\text{Fossa iliaca width}}{\text{Sacral surface width}} \times 100$	394	353	305
Length of *humerus:* average	404 mm.	389 mm.	300 mm.
$\frac{\text{Radius length}}{\text{Humerus length}} \times 100$	80.7	85.5	92.6
$\frac{\text{Humerus + Radius length}}{\text{Femur + Tibia length}} \times 100$	117.0	112.4	107.7
Hand: $\frac{\text{Ray I length}}{\text{Ray III length}} \times 100$	44.6 (42.1–46.4)	49.8 (48.0–52.0)	39.5
Foot: $\frac{\text{Ray I length}}{\text{Ray III length}} \times 100$	64.8 (60.0–68.8)	72.9 (68.8–77.5)	66.5
Relative height of tarsal joint for hallux	30–42	21	44–50
Angle of direction of this joint	18–30°	35–39°	15–24°
Outer toes II, III, and IV	short	extremely short	long

tain gorilla seems to be in general somewhat more highly specialized. In regard to a number of characters the latter approaches man more closely than does any other primate. Particularly the limb skeletons of mountain gorilla and of man show numerous striking similarities.

All these results of taxonomic interest, together with their phylogenetic implications, are diagrammatically illustrated by the pedigree in figure 23. It must be emphasized that this "family-tree" is based primarily upon the results of this paper, and that this particular arrangement of branching of the divergent phylogenetic lines renders the skeletal differences between recent primates most easily and most

consistently understandable. Practically the same pedigree was found most suitable for the interpretation of the author's (1927) findings regarding the growth and body proportions of higher primates. This former paper contained also a general discussion of this pedigree. Additional and more detailed comment on the author's views regarding the phylogeny of higher primates is best postponed until the results of certain other related studies have been published.

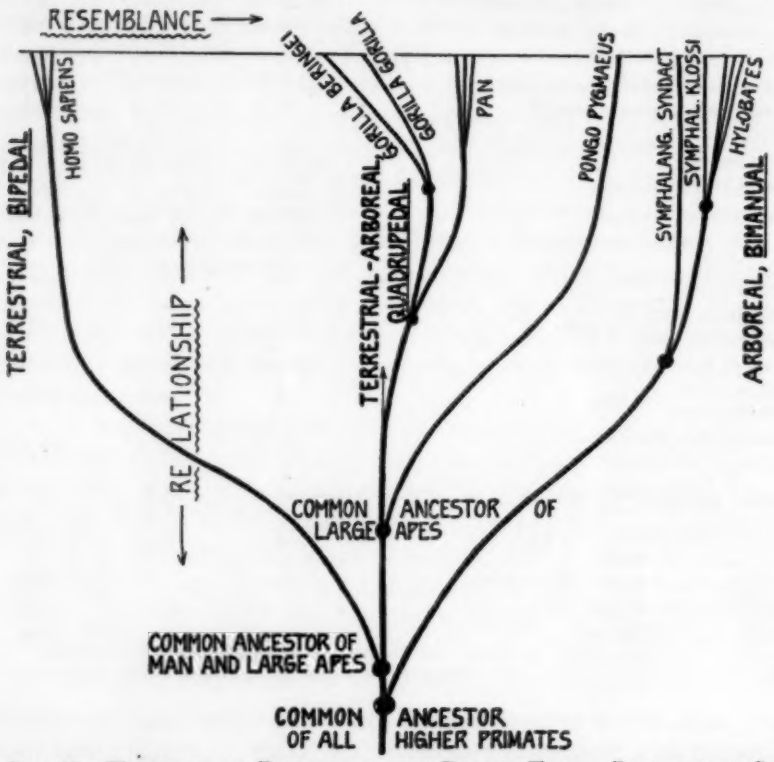

FIG. 23. HYPOTHETICAL PEDIGREE OF THE RECENT HIGHER PRIMATES, AS SUPPORTED BY THE RESULTS OF THIS PAPER. The approximate degrees of resemblance are indicated by the horizontal distances between the various branches; the most probable degrees of phylogenetic relationship are roughly represented by the perpendicular distances to the points of spreading.

The skeletal parts discussed in the preceding chapters showed great differences in regard to the degree of uniformity they maintain in at least the higher primates. Whereas some structures seem to have remained practically untouched by the many divergent primate special-

izations, others have developed with differing intensity or direction in nearly every genus, and this frequently without our being able to discover any plausible reason for these differences. Thus it has been demonstrated that the number of vertebrae is among all primates very constant in the cervical region but highly variable in the caudal portion of the spine. The relative width of the supraspinal fossa of the scapula varies less widely among primates than does the relative width of the infraspinal fossa. The proportionate lengths of the pubis and of the ischium are far more uniform and conservative than the measurable features of the ilium of monkeys, apes, and man. Smaller differences exist between the various primates in regard to the proportion between tibia and femur than in regard to that between radius and humerus. The skeleton of the foot has been found to be much more plastic in the course of evolution than that of the hand. Within the foot, however, the metatarsi II to V maintain a surprisingly constant relative length, whereas the tarsus and the phalanges react readily to differing functions by changing their proportionate length with apparent ease.

Different structures vary with widely differing intensity not only *inter*generically but also *intra*generically or, rather, *intra*specifically, INDIVIDUAL variations having been found to be much more common in some bodily parts than in others. For instance, among higher primates the number of coccygeal vertebrae varies individually and within one and the same species much more than the number of sacral vertebrae, but the latter varies more than the number of thoracolumbar vertebrae, which in turn is much less stable than the number of cervical vertebrae. The proportion between the clavicle and the humerus is individually much more constant than the various proportions appertaining to the scapula, but the variability of the latter is surpassed by the indices of the sternum, especially the *corpus sterni*, which is one of the most variable bones in the body.

In regard to the numerical variations of the vertebrae man is much more stable than the apes, siamangs, and gibbons, but equally or less stable than some of the lower primates. The variability of the proportions between the limb bones, on the other hand, is considerably higher in man than in the apes. Within each species every structure has its own characteristic tendency to deviate from the average condition, but different primates may be widely different in regard to the degree of variability in the same structure.

This study has contributed still further data bearing on variability, namely the results concerning bilateral variations, or asymmetries.

Just as in the case of individual variations in the limb proportions, so are asymmetries in the limb bones more frequent and more pronounced in man than in the apes. Asymmetries favoring as a rule one particular side are found more frequently in the upper than in the lower extremity and are more common in man than in the apes. In all primates the clavicle is more asymmetrical than the limb bones.

All the skeletal structures of the trunk and limbs of higher primates can individually deviate from the "type" of the species with such frequency and intensity, that specimens of different species or even genera are often distinguishable only by the combination of variations in a number of structures. This at times very abundant supply of variations provides many possibilities for selective processes, leading to further evolutionary changes in the higher primates.

BIBLIOGRAPHY

Adolphi, H. 1905. Ueber die Variationen des Brustkorbes und der Wirbelsäule. *Morphol. Jahrb.*, XXXIII, 39–86.

———. 1912. Ueber den Bau des menschlichen Kreuzbeines und die Verschiedenheit seiner Zusammensetzung in Prag und Jurjew-Dorpat. *Morphol. Jahrb.*, XLIV, 119–125.

Aeby, C. 1878. Beiträge zur Osteologie des Gorilla. *Morphol. Jahrb.*, IV, 288–313.

Bardeen, C. R. 1904. Numerical vertebral variation in the human adult and embryo. *Anatom. Anzeiger*, XXV, 497–519.

Bardeleben, K. v. 1909. Ueber bilaterale Asymmetrie beim Menschen und bei höheren Tieren. *Anatom. Anzeiger*, XXXIV, Ergzh. 2–72.

Bateson, W. 1894. Materials for the Study of Variation. *London.*

Bolk, L. 1898. Beitrag zur Neurologie der unteren Extremität der Primaten. *Morphol. Jahrb.*, XXI, 305–361.

———. 1926. Vergleichende Untersuchungen an einem Fetus eines Gorillas und eines Schimpansen. *Zeitschr. f. Anat. u. Entwicklungsgesch.*, LXXXI, 1–89.

Boltze, P. 1926. Beiträge zur Anatomie des Knochengerüstes von *Hylobates syndactilus*. *Morphol. Jahrb.*, LVI, 317–401.

Brandes, G. 1929. Die Backenwülste des Orang-Mannes. *Der Zoolog. Garten*, I, 365–368.

Breitenbecher, J. K. 1923. Hereditary shortness of thumbs. *J. of Heredity*, XIV, 15–22.

Broca, P. 1869. L' ordre des primates. Parallèle anatomique de l'homme et des singes. *Bull. de la Soc. d'Anthropol. de Paris*, Sér. 2, IV, 228–401.

Broek, A. J. P. v. d. 1908. Ueber einige anatomische Merkmale von *Ateles*, in Zusammenhang mit der Anatomie der Platyrrhinen. *Anatom. Anzeiger*, XXXIII, 111–124.

Coolidge, H. J., Jr. 1929. A revision of the genus *Gorilla*. *Memoirs, Mus. of Comp. Zoology, Harvard*, L, 291–383.

CUNNINGHAM, D. J. 1886. The lumbar curve in man and the apes. *Roy. Irish Acad., "Cunningham Memoirs,"* II, *Dublin.*

DELISLE, F. 1895. Notes sur l' ostéométrie et la craniologie des orang-outans. *Nouv. Arch. du Muséum d'Histoire Naturelle,* Sér. 3, VII, 83–114.

DENIKER, J. 1885. Recherches anatomiques et embryologiques sur les singes anthropoïdes. Foetus de gorille et de gibbon comparés aux foetus humains et aux anthropoïdes jeunes et adultes. *Arch. de Zoöl. Expérim. et Géner.,* Sér. 2, III, Suppl., 1–265.

DU CHAILLU, P. B. 1861. Explorations and Adventures in Equatorial Africa. *New York.*

DUVERNOY, G. L. 1856. Des caractères anatomiques des grands singes pseudo-anthropomorphes. *Arch. du Muséum d' Histoire Naturelle,* VIII, 1–248.

EISLER, P. 1892. Der Plexus lumbo-sacralis des Menschen. *Abhdl. d. Naturforsch. Gesell. zu Halle,* XVII.

ELLIOT, D. G. 1913. A Review of the Primates. *Monograph I, Amer. Mus. Nat. Hist., New York.*

FICK, R. 1895. Vergleichend anatomische Studien an einem erwachsenen Orang-Utang. *Arch. f. Anat. u. Physiol., Anatom. Abth.,* 1–100.

———. 1895. Beobachtungen an einem zweiten erwachsenen Orang-Utang und einem Schimpansen. *Arch. f. Anat. u. Physiol., Anatom. Abth.,* 289–318.

———. 1926. Massverhältnisse an den oberen Gliedmassen des Menschen und den Gliedmassen der Menschenaffen. *Sitzungsber. d. Preuss. Akad. d. Wissensch., Phys.-mathem. Kl.,* XXX, 417–451.

FISCHEL, A. 1906. Untersuchungen über die Wirbelsäule und den Brustkorb des Menschen. *Anatom. Hefte,* XXX, 459–588.

FLOWER, W. H. 1862. Notes on the anatomy of *Pithecia monachus* (Geoff.). *Proceed. Zool. Soc., London,* 326–333.

———. 1884. Catalogue of the Specimens Illustrating the Osteology and Dentition of Vertebrated Animals, Recent and Extinct, Contained in the Museum of the Royal College of Surgeons of England. Part II, Mammalia. *London.*

———. 1888. Einleitung in die Osteologie der Säugethiere. *Leipzig.*

FRETS, G. P. 1909. Ueber die Varietäten der Wirbelsäule und ihre Erblichkeit. *Verhdl. d. anatom. Gesell., Giessen,* 105–119.

FREY, H. 1918. Beitrag zum Umbildungsprozess des Brustkorbes. *Vierteljahrsschr. Naturforsch. Gesell., Zürich,* LXIII, 34–98.

———. 1923. Untersuchungen über die Scapula, speciell über ihre äussere Form und deren Abhängigkeit von der Funktion. *Zeitschr. f. Anat. u. Entwicklungsgesch.,* LXVIII, 277–324.

———. 1924. Weitere Untersuchungen über die Scapula, speziell über die Scapula scaphoides. *Zeitschr. f. Anat. u. Entwicklungsgesch.,* LXXIV, 240–284.

———. 1929. Untersuchungen über das Rumpfskelett. *Morphol. Jahrb.,* LXII, 355–463.

FRIEDENTHAL, H. 1910. Sonderformen der menschlichen Leibesbildung. Beiträge z. Naturgesch. d. Menschen, V, *Jena.*

GAUPP, E. 1909. Die normalen Asymmetrien des menschlichen Körpers. Sammlung anatom. u. physiolog. Vorträge u. Aufsätze, H. 4. *Jena.*

GIEBEL, C. G. 1877. Mammalia. Bronn's Klassen u. Ordnungen des Thier-Reichs, VI, 5. Abth., *Leipzig.*

GRAVES, W. W. 1910. The scaphoid scapula, a frequent anomaly in development of hereditary, clinical, and anatomical significance. *Medical Record,* May 21.

GRAVES, W. W. 1911. The scaphoid scapula syndrome; its connection with syphilis in the ascendants. *Interstate Med. Journ.,* XVIII.

———. 1924. The relations of scapular types to problems of human heredity, longevity, morbidity and adaptability in general. *Arch. of Intern. Medicine,* XXXIV, 1–26.

GREGORY, W. K. 1910. The orders of mammals. *Bull. Amer. Mus. Nat. Hist.,* XXVII, 1–524.

———. 1928. Were the ancestors of man primitive brachiators? *Proceed. Amer. Philos. Soc.,* LXVII, 129–150.

———. 1928. The upright posture of man: a review of its origin and evolution. *Proceed. Amer. Philos. Soc.,* LXVII, 339–374.

HARTMANN, R. 1889. Anthropoid Apes. Internat. Scientific Series, LIII, *London.*

HASEBE, K. 1913. Die Wirbelsäule der Japaner. *Zeitschr. f. Morphol. u. Anthropologie,* XV, 259–380.

HOLLAND, W. J. 1924. Account of a skeleton of a gorilla remarkable because showing recovery from gunshot wounds. *Annals of the Carnegie Mus.,* XV, 293–296.

HOOTON, E. A. 1930. Doubts and suspicions concerning certain functional theories of primate evolution. HUMAN BIOLOGY, II, 223–249.

HULTKRANTZ, J. W. 1897. Das Ellbogengelenk und seine Mechanik. *Jena.*

HUNTINGTON, G. S. 1918. Modern problems of evolution, variation and inheritance in the anatomical part of the medical curriculum. *Anatom. Record,* XIV, 359–412.

KEITH, A. 1903. The extent to which the posterior segments of the body have been transmuted and suppressed in the evolution of man and allied primates. *J. Anat. & Physiol.,* XXXVII, 18–40.

KEITH, A. 1927. Concerning Man's Origin. *London.*

KEMPERMANN, C. T. 1929. Ein Beitrag zum Problem der Regionbildung der Wirbelsäule. *Morphol. Jahrb.,* LX, 560–612.

KLOSS, C. B. 1929. Some remarks on the gibbons, with the description of a new subspecies. *Proceed. Zoolog. Soc., London,* 113–127.

KOGANEI. 1894. Beiträge zur physischen Anthropologie der Aino. *Mittheil. a. d. Medizin. Fakultät d. Kaiserl. Japan. Univers.,* II, 1–404.

KOHLBRÜGGE, J. H. F. 1891. Versuch einer Anatomie des Genus Hylobates. Zoolog. Ergebn. einer Reise in Niederländ. Ost-Indien, I, 211–354. *Leiden.*

KRAUSE, W. 1897. Ueber das weibliche Sternum. *Internat. Monatsschr. f. Anat. u. Physiol.,* XIV, 21.

KUNITOMO, K. 1918. The development and reduction of the tail and of the caudal end of the spinal chord. *Contribut. to Embryology,* XI, *Carnegie Inst. Wash. Publ.* No. 271, 161–198.

LAZARUS, S. P. 1896. Zur Morphologie des Fuszskeletts. *Morphol. Jahrb.,* XXIV, 1–166.

LEBOUCQ, H. 1882. Le développement du premier métatarsien et de son articulation tarsienne chez l'homme. *Arch. de Biologie*, III, 336–344.

LE DOUBLE, A. F. 1912. Traité des variations de la colonne vertébrale de l' homme. *Paris.*

LORENZ V. LIBURNAU, L. 1917. Beitrag zur Kenntnis der Affen und Halbaffen von Zentralafrika. *Ann. d. k. k. Naturhist. Hofmuseums, Wien*, XXXI, 169–241.

LUCAE, I. C. 1864–65. Die Hand und der Fuss. *Abhdl. Senkenberg. Naturforsch. Gesell.*, V, 275.

LYON, M. W. 1911. Mammals collected by Dr. W. L. Abbott on Borneo and some of the small adjacent islands. *Proceed. U. S. National Mus.*, XL, 53–146.

MANOUVRIER, L. 1882. Recherches d'anatomie comparative et d'anatomie philosophique sur les caractères du crâne et du cerveau. *Bull. de la Soc. Zoolog. de France*, VII.

MARTIN, R. 1928. Lehrbuch der Anthropologie in systematischer Darstellung. *Jena.*

MEYER, A. W. 1915. Fusion of three cervical vertebrae in a gorilla. Spolia Anatomica Addenda I. *Anatom. Record*, IX, 500–501.

MILLER, G. S., JR. 1920. Conflicting views on the problem of man's ancestry. *Amer. J. Phys. Anthrop.*, III, 213–245.

———. 1929. The controversy over human "missing links." Smithsonian Report for 1928, 413–465.

MOHR, O. L., and C. WRIEDT. 1919. A new type of hereditary brachyphalangy in man. *Carnegie Inst. Wash. Publ.* No. 295.

MOLLISON, T. 1911. Die Körperproportionen der Primaten. *Morphol. Jahrb.*, XLII, 79–304.

MORTON, D. J. 1922. Evolution of the human foot. I. *Amer. J. Phys. Anthrop.*, V, 305–336.

———. 1926. Evolution of man's erect posture. *J. of Morphol. & Physiol.*, XLIII, 147–179.

NISHI, K. 1928. Beiträge zum Studium der Präsakralwirbel bei verschiedenen Menschenrassen. *Folia Anat. Japonica*, VI, 1–101.

OSBORN, H. F. 1927. Man Rises to Parnassus. *Princeton Univ. Press.*

———. 1930. The discovery of tertiary man. *Science*, LXXI, 1–7.

PATERSON, A. M. 1893–06. The human sacrum. *Scient. Transact. Roy. Dublin Soc.*, Ser. 2, V, 123–204.

POCOCK, R. I. 1927. The gibbons of the genus *Hylobates*. *Proceed. Zoolog. Soc., London*, 719–741.

RADLAUER, C. 1908. Beiträge zur Anthropologie des Kreuzbeines. *Morphol. Jahrb.*, XXXVIII, 323–447.

RANKE, K. 1897. Muskel- und Nervenvariationen der dorsalen Elemente des Plexus ischiadicus der Primaten. *Arch. f. Anthropol.*, XXIV, 117–144.

ROSENBERG, E. 1875. Ueber die Entwicklung der Wirbelsäule und das Centrale carpi des Menschen. *Morphol. Jahrb.*, I, 83–197.

———. 1912. Ueber die Wirbelsäule des Menschen als Objekt wissenschaftlicher Arbeit im Präpariersaal. *Verhdl. anatom. Gesell., München*, 119–130.

RUGE, G. 1891. Anatomisches über den Rumpf der Hylobatiden. Ein Beitrag zur Bestimmung der Stellung dieses Genus im Systeme. Zoolog. Ergebn. einer Reise in Niederländ. Ost-Indien, I, 366–460. *Leiden.*

SCHINZ, H. R. 1922. Das Foramen supratrochleare humeri. *Fortschr. auf. d. Gebiete d. Röntgenstrahlen*, XXIX, 193–200.

SCHULTZ, A. H. 1918. The position of the insertion of the pectoralis major and deltoid muscles on the humerus of man. *Amer. J. of Anat.*, XXIII, 155–173.

———. 1923. Fetal growth in man. *Amer. J. Phys. Anthrop.*, VI, 389–399.

———. 1924. Observations on *Colobus* fetuses. *Bull. Amer. Mus. Nat. Hist.*, XLIX, 443–457.

———. 1924. Growth studies on primates bearing upon man's evolution. *Amer. J. Phys. Anthrop.*, VII, 149–164.

———. 1925. Embryological evidence of the evolution of man. *J. Wash. Acad. of Sciences*, XV, 247–263.

———. 1926. Studies on the variability of platyrrhine monkeys. *J. of Mammalogy*, VII, 286–305.

———. 1926. Anthropological studies on Nicaraguan Indians. *Amer. J. Phys. Anthrop.*, IX, 65–80.

———. 1926. Variations in man and their evolutionary significance. *Amer. Naturalist*, LX, 297–323.

———. 1926. Fetal growth of man and other primates. *Quarterly Review of Biology*, I, 465–521.

———. 1927. Studies on the growth of gorilla and of other higher primates with special reference to a fetus of gorilla, preserved in the Carnegie Museum. *Memoirs, Carnegie Museum*, XI, 1–86.

———. 1929. The technique of measuring the outer body of human fetuses and of primates in general. *Contribut. to Embryology*, No. 117, *Carnegie Inst. Wash.* Pub. No. 394, 213–257.

———. 1930. Notes on the growth of anthropoid apes with especial reference to deciduous dentition. *Report of the Laboratory & Museum of Comp. Pathology, Zoolog. Soc., Philadelphia*, 34–45.

SCHWALBE, G. 1916. Ueber das Intermetatarseum. *Zeitschr. f. Morphol. u. Anthropol.*, XX, 1–50.

SCHWERZ, F. 1912. Die Alamannen in der Schweiz. *Zeitschr. f. Morphol. u. Anthropol.*, XIV, 609–700.

SLOMANN, H. C. 1926. Perforatio humeri. *Videnskale Meddel. Dansk Naturhist. Forening*, LXXXII, 271–314.

SPERINO, G. 1897. Anatomia del Cimpanze. *Torino.*

STRAUS, W. L. JR. 1927. Growth of the human foot and its evolutionary significance. *Contribut. to Embryology*, No. 101, *Carnegie Inst. Wash.* Pub. No. 380, 93–134.

———. 1929. Studies on primate ilia. *Amer. J. Anat.*, XLIII, 403–460.

STRUTHERS, J. 1893. On the articular processes of the vertebrae in the gorilla compared with those in man, and on costo-vertebral variation in the gorilla. *J. Anatom. & Physiol.*, XXVII, 131–138.

SYMINGTON, J. 1890. The vertebral column of a young gorilla. *J. Anatom. & Physiol.*, XXIV, 42–51.

TODD, T. W. 1922. Numerical significance in the thoracicolumbar vertebrae of the mammalia. *Anatom. Record*, XXIV, 261–286.

———. 1924. Stability. *Scientific Monthly*, XIX, 632–634.

TREDGOLD, A. F. 1897. Variations of ribs in the primates with especial reference to the number of sternal ribs in man. *J. Anatom. & Physiol.*, XXXI, 288–302.

TRINCHESE, S. 1870. Descrizione di un feto di orang-utan. *Ann. d. Mus. Civico d. Storia Nat. d. Genova*, I, 9–46.

TROTTER, M. 1929. The vertebral column in whites and in American negroes. *Amer. J. Phys. Anthrop.*, XIII, 95–107.

TYSON, E. 1699. Orang-outang, sive homo sylvestris. *London.*

VIRCHOW, H. 1917. Ueber Fuszskelette farbiger Rassen. *Berlin.*

VOLKOV, T. 1903/04. Les variations squelettiques du pied chez les primates et dans les races humaines. *Bull. et Mém. Soc. Anthrop., Paris*, Sér. 5, IV, 632–708; V, 1–50, 201–331.

WATERMAN, H. C. 1929. Studies on the evolution of the pelvis of man and other primates. *Bull. Amer. Mus. Nat. Hist.*, LVIII, 585–642.

WEIDENREICH, F. 1913. Ueber das Hüftbein und das Becken der Primaten und ihre Umformung durch den aufrechten Gang. *Anatom. Anzeiger*, XLIV, 497–513.

———. 1921. Der Menschenfuss. *Zeitschr. f. Morphol. u. Anthropol.*, XXII, 51–282.

WESTENHÖFER, M. 1929. Die Stellung des menschlichen Beckens in der Wirbeltierreihe. *Arch. f. Frauenkunde u. Konstitutionsforsch.*, XV, 215–261.

WESTLING, C. 1884. Beiträge zur Kenntnis des peripherischen Nervensystems. *Bihang till K. Svenska Vet.-Akad. Handlingar*, IX.

WIEDERSHEIM, R. 1908. Der Bau des Menschen als Zeugnis für seine Vergangenheit. *Tübingen.*

WILLIS, T. A. 1923. The thoracicolumbar column in white and negro stocks. *Anatom. Record*, XXVI, 31–40.

WOOD JONES, F. 1929. The distinctions of the human hallux. *J. of Anatomy*, LXIII, 408–411.

———. 1929. Man's Place among the Mammals. *New York.*

YERKES, R. M., AND A. W. YERKES. 1929. The Great Apes. A study of anthropoid life. *New Haven.*

[NOTE: The author desires to acknowledge, with gratitude, his indebtness to the National Academy of Sciences for a grant to aid in the publication of this paper.]

APPENDIX

TABLES OF BASIC DATA

TABLE I

The Number of Vertebrae in the Precaudal Regions of the Spine in the Platyrrhine Genus ALOUATTA. All Specimens Had 7 Cervical Vertebrae

SPECIES	COLLECTION	OBSERVED BY	THORAC.	LUMBAR	THOR. L.	SACRAL
seniculus	A. Hopk.	Schultz	14	5	19	3
"	Sch. 763	"	14	5	19	3
"	Zo. I. Z.	"	14	5	19	3
"	Zo. I. Z.	"	14	5	19	3
"	A. Hopk. C 34A	"	14	5	19	3
"	A. Hopk. C 34B	"	14	5	19	3
"	Sch.	"	14	5	19	3
"	Nat. M. 49795	"	14	5	19	3
"	Nat. M. 113435	"	14	6	20	3
"	.....	Flower, 1862	14	5	19	3
"	.....	Flower, 1884	13	5	18	3
palliata	A. Hopk.	Schultz	14	5	19	3
"	Sch. 541	"	14	5	19	3
"	Sch. 607	"	14	5	19	3
"	Nat. M. 240409	"	14	5	19	3
"	Nat. M. 240406	"	13	6	19	3
"	W. R. U.	Todd, 1922	..	..	20	..
ursina	.....	Flower, 1862	14	5	19	3
"	.....	Ranke, 1897	13	5	18	3
"	.....	Ranke, 1897	13	5	18	3
villosus	Nat. M. 49329	Schultz	15	5	20	4
"	Nat. M. 49330	"	15	5	20	4
insulanus	Nat. M. 236915	"	15	5	20	3
species?	.....	Ranke, 1897	14	5	19	3
"	.....	Ranke, 1897	14	5	19	3

TABLE II

The Number of Vertebrae in the Precaudal Regions of the Spine in the Platyrrhine Genus CEBUS. All Specimens Had 7 Cervical Vertebrae. In This and the Following Tables Some of the Old Species Names Were Changed to Those Given by Elliott (1913), *e. g., "Cebus Hypoleucus E. Geoff." of Flower and of Giebel to Cebus Capucinus (Linnaeus) or "C. Robustus" of Giebel to C. Variegatus.*

SPECIES	COLLECTION	OBSERVED BY	THORAC.	LUMBAR	THOR. L.	SACRAL
capucinus	Sch. 608	Schultz	14	6	20	3
"	Sch. 837	"	14	6	20	3
"	Sch. 841	"	14	6	20	3
"	Sch. 852	"	14	6	20	3
"	P. A. L.	"	14	6	20	3
"	.....	Flower, 1862	14	5	19	3
"	.....	Flower, 1862	12	7	19	3
"	.....	Giebel, 1877	14	6	20	3
"	.....	Giebel, 1877	15	6	21	3
"	.....	Giebel, 1877	13	6	19	2
"	.....	Flower, 1884	14	6	20	3
"	.....	Flower, 1884	14	5	19	3
"	.....	Flower, 1884	13	6	19	3
"	.....	Ranke, 1897	14	4	18	3
"	.....	Ranke, 1897	13	6	19	3
"	.....	v. d. Broek, 1908	13	6	19	3
apella	.....	Ranke, 1897	12	7	19	3
"	.....	Ranke, 1897	15	5	20	3
"	.....	Flower, 1862	14	5	19	3
fatuellus	.....	Flower, 1862	14	5	19	3
"	.....	Giebel, 1877	14	5	19	3
"	.....	Giebel, 1877	14	6	20	3
variegatus	.....	Giebel, 1877	14	5	19	3
"	.....	Giebel, 1877	15	5	20	3
"	.....	Giebel, 1877	15	5	20	3
cirrifer	.....	Giebel, 1877	14	6	20	3
"	.....	Flower, 1862	14	5	19	3
albifrons	Nat. M. 24948	Schultz	14	6	20	3
macrocephalus	.....	Ranke, 1897	14	5	19	3
unicolor	W. R. U.	Todd, 1922	..	..	19	..
"speciosus"	.....	v. d. Broek, 1908	14	6	20	3
"	.....	v. d. Broek, 1908	14	6	20	3
"	.....	v. d. Broek, 1908	14	5	19	3
"	.....	v. d. Broek, 1908	13	6	19	3
species ?	Nat. M. 22210	Schultz	14	6	20	3
"	Nat. M. 805	"	14	6	20	3
"	.....	Rosenberg, 1875	14	6	20	3
"	.....	Flower, 1884	14	5	19	3

TABLE III

The Number of Vertebrae in the Precaudal Regions of the Spine in the Platyrrhine Genus ATELES. All Specimens Had 7 Cervical Vertebrae. (It Is Not Impossible That the Species "Ateles Hypoxanthus" and "A. Arachnoides" Belong Really to the Closely Allied Genus Brachyteles.)

SPECIES	COLLECTION	OBSERVED BY	THORAC.	LUMBAR	THOR. L.	SACRAL
paniscus	.....	Flower, 1862	13	4	17	3
"	.....	Giebel, 1877	14	4	18	3
"	.....	Ranke, 1897	14	4	18	3
"	.....	Ranke, 1897	14	4	18	3
"	.....	Sperino, 1897	..	..	18	..
"	.....	v. d. Broek, 1908	14	4	18	3
geoffroyi	Sch. 819	Schultz	14	4	18	3
"	.....	Flower, 1862	14	4	18	3
"	.....	Flower, 1884	14	4	18	3
belzebuth	.....	Flower, 1862	14	4	18	3
"	.....	Flower, 1862	13	4	17	3
"	W. R. U.	Todd, 1922	..	..	17	..
marginatus	.....	Ranke, 1897	14	4	18	3
"hypoxanthus"	.....	Ranke, 1897	14	4	18	4
"	.....	Giebel, 1877	14	4	18	3
"arachnoides"	.....	Flower, 1862	14	4	18	3
"chameck" (?)	.....	Flower, 1862	14	4	18	3
species?	.....	Ranke, 1897	14	4	18	3
"	Nat. M. 984	Schultz	14	4	18	3
"	Nat. M. 49712	"	14	4	18	3
"	Nat. M. 49888	"	14	4	18	3
"	Nat. M. 154189	"	14	4	18	3

TABLE IV

The Number of Vertebrae in the Precaudal Regions of the Spine in the Catarrhine Genus PITHECUS. All Specimens Had 7 Cervical Vertebrae

SPECIES	COLLECTION	OBSERVED BY	THORAC.	LUMBAR	THOR. L.	SACRAL
rhesus	Sch. 149	Schultz	12	7	19	3
"	Sch. 209	"	12	7	19	3
"	Sch. 333	"	12	7	19	3
"	Sch. 905	"	12	6	18	3
"	P. A. L.	"	12	7	19	3
"	P. A. L. 16	"	12	7	19	3
"	P. A. L. 17	"	12	7	19	3
"	A. Hopk.	"	12	7	19	3
"	Carnegie Col. 4	"	12	7	19	3
"	Carnegie Col. 55	"	12	7	19	3
"	Nat. M. 49436	"	13	6	19	3
"	.....	Flower, 1884	12	7	19	3
"	.....	Flower, 1884	12	7	19	3
"	.....	Flower, 1884	12	7	19	3
"	.....	Flower, 1884	12	7	19	3
"	.....	Flower, 1884	12	7	19	3
"	W. R. U.	Todd, 1922	..	..	16	..
"	W. R. U.	Todd, 1922	..	..	19	..
irus	Nat. M. 49683	Schultz	12	7	19	3
"	.....	Giebel, 1877	12	7	19	3
"	.....	Giebel, 1877	12	6	18	3
"	.....	Flower, 1884	12	7	19	3
"	.....	Flower, 1884	12	6	18	3
"	.....	Flower, 1884	13	6	19	3
"	.....	Ranke, 1897	12	7	19	3
"	.....	Ranke, 1897	12	7	19	3
"	.....	Ranke, 1897	12	7	19	3
nemestrinus	Nat. M. 49691	Schultz	12	7	19	3
"	.....	Giebel, 1877	12	7	19	3
"	.....	Giebel, 1877	13	6	19	3
"	.....	Flower, 1884	12	7	19	3
"	.....	Ranke, 1887	12	7	19	3
"	.....	Ranke, 1897	12	7	19	3
"	.....	Ranke, 1897	12	7	19	3
"	W. R. U.	Todd, 1922	..	..	19	..
lasiotis	Nat. M. 240008	Schultz	12	7	19	3
"	Nat. M. 240010	"	12	7	19	3
sinicus	Nat. M. 16362	"	12	7	19	3
"	.....	Flower, 1884	12	7	19	3
pileatus	.....	Flower, 1884	12	7	19	3
fuscatus	Nat. M. 20936	Schultz	12	6	18	3
fascicularis	Nat. M. 49696	"	13	6	19	3
"*maurus*"	Nat. M. 22445	"	12	7	19	3
"*inuus*"	Nat. M. 200951	"	12	7	19	3
"*inius*"	.....	Flower, 1884	12	7	19	3
"*ecaudatus*"	.....	Ranke, 1897	12	7	19	3
"	.....	Ranke, 1897	12	7	19	3
species ?	.....	Ranke, 1897	12	7	19	3
"	.....	Ranke, 1897	12	7	19	3
"	Nat. M. 154367	Schultz	12	7	19	3
"	Nat. M. 173813	"	12	7	19	3
"	Nat. M. 174083	"	12	7	19	3
"	Nat. M. 22706	"	12	7	19	3

TABLE V

The Number of Vertebrae in the Different Spinal Regions in the Genus HYLOBATES. All Specimens Had 7 Cervical Vertebrae

SPECIES	COLLECTION	OBSERVED BY	THORAC.	LUMBAR	THOR. L.	SACRAL	COCCYG.	TOTAL
concolor	Nat. M. 154372	Schultz	13	4	17	5	1	30
"	Nat. M. 198840	"	13	4	17	4	3	31
"	Nat. M. 153799	"	13	5	18	4	2	31
"	Nat. M. 154373	"	13	5	18	4	2	31
"	Nat. M. 151833	"	13	5	18	4	2	31
"	Nat. M. 151835	"	13	5	18	4	2	31
"	Nat. M. 151832	"	13	5	18	4	2	31
"	Nat. M. 153801	"	13	5	18	4	2	31
"	Nat. M. 153797	"	13	5	18	4	2	31
"	Nat. M. 154371	"	13	5	18	4	2	31
"	Nat. M. 151834	"	13	5	18	4	2	31
"	Nat. M. 154370	"	12	6	18	5	1	31
"	Nat. M. 151837	"	13	5	18	5	1	31
"	Nat. M. 153798	"	13	5	18	5	2	32
"	Nat. M. 154412	"	13	5	18	5	3	33
"	W. R. U. B 160	Straus	13	5	18	4	..	..
"	W. R. U. B 162	Todd, 1922	..	..	18	..	..	..
"	W. R. U. B 161	Todd, 1922	..	..	17	..	..	..
"	Museum Leiden	Kohlbrügge, 1891	12	5	17	5	2	31
leuciscus	Nat. M. 154722	Schultz	13	5	18	4	3	32
"	Nat. M. 156296	"	13	5	18	4	4	33
"	.....	Cuvier (Kohlbrügge) ...	12	5	17	4	3	31
"	Museum Leiden	Kohlbrügge, 1891	12	5	17	4	3	31
"	Museum Leiden	Kohlbrügge, 1891	13	5	18	4	3	32
"	Museum Leiden	Kohlbrügge, 1891	13	5	18	4	3	32
"	Amsterdam	Kohlbrügge, 1891	13	5	18	4	4	33
"	.....	Owen (Rosenberg)	13	5	18	5	2	32
"	Munich	Ranke, 1897	13	5	18	5	..	..
"	Munich	Ranke, 1897	14	4	18	4	..	..
"	Anat. Zürich	Ruge, 1891	..	..	18	..	..	..
agilis	Zo. I. Z. 136	Schultz	12	6	18	4	2	31
"	Nat. M. 49694	"	12	5	17	5	3	32
"	Nat. M. 49697	"	13	5	18	5	3	33
"	Paris	Deniker, 1885	13	5	18	5	4	34
"	.....	Cunningham, 1886	13	5	18	..	..	..
"	.....	Hartmann, 1899	13	6	19	5	4	35
"	Museum Leiden	Kohlbrügge, 1891	13	5	18	4	5	34
"	.....	Kohlbrügge, 1891	13	5	18	..	..	..
"	Anat. Zürich	Ruge, 1891	..	..	18	..	..	..
"	Anat. Zürich	Ruge, 1891	..	..	18	..	..	..
lar	Zo. I. Z. 48	Schultz	13	5	18	4	1	30
"	Zo. I. Z. 130	"	13	5	18	4	1	30
"	Sch. 907	"	13	5	18	5	3	33
"	Nat. M. 49463	"	13	5	18	5	..	..
"	Roy. Col.. Surg.	Flower, 1884	13	5	18	5	2	32
"	Roy. Coll. Surg.	Flower, 1884	13	5	18	5	2	32
"	Anat. Zürich	Ruge, 1891	..	..	18	..	..	..
"	Munich	Ranke, 1897	13	5	18	4	..	..
"	G. Max	Ranke, 1897	13	5	18	4	..	..
"	Anat. Halle	Boltze, 1926	13	5	18	4	3	32
hoolock	W. R. U. B 159	Straus	13	4	17	5	..	..
"	Columbia U.	Huntington, 1918	12	5	17	..	..	..
species ?	Nat. Mus. 240495	Schultz	14	5	19	5	4	35
"	.....	Rosenberg, 1876	14	5	19	4	4	34
"	Roy. Coll. Surg.	Flower, 1884	13	5	18	5	2	32
"	Roy. Coll. Surg.	Flower, 1884	14	4	18	5	..	..
"	.....	Paterson, 1893	13	5	18	5	3	33
"	.....	Paterson, 1893	13	5	18	5	3	33
"	.....	Paterson, 1893	13	5	18	4	3	32
"	Anat. Halle	Boltze, 1926	13	5	18	4	5	34
"	Anat. Halle	Boltze, 1926	14	5	19	4	2	32
"	Anat. Halle	Boltze, 1926	12	5	17	4	4	32
"	Anat. Halle	Boltze, 1926	12	5	17	4	3	31

TABLE VI

The Number of Vertebrae in the Different Spinal Regions in the Genus SYMPHALANGUS. The Third Specimen of Kohlbrügge Has 8 Cervical Vertebrae, All Others 7

SPECIES	COLLECTION	OBSERVED BY	THORAC.	LUMBAR	THOR. L.	SACRAL	COCCYG.	TOTAL
klossi	Nat. M. 49656	Schultz	13	5	18	5	5	35
"	Nat. M. 49657	"	13	6	19	4	5	35
syndactylus	Nat. M. 115678	"	13	5	18	4	3	32
"	Nat. M. 49746	"	13	5	18	4	3	32
"	Nat. M. 49748	"	13	5	18	4	2	31
"	Sch. 130	"	13	5	18	4	2	31
"	Nat. M. 49747	"	13	4	17	5	1	30
"	Paris	Duvernoy, 1856	13	5	18	4	3	32
"	.....	Daubenton(Kohlbrügge)	12	6	18	3	3	31
"	.....	Vrolik (Ranke)	13	5	18	4	..	..
"	Roy. Coll. Surg.	Flower, 1884	13	4	17	4	4	32
"	Roy. Coll. Surg.	Flower, 1884	13	4	17	5	..	..
"	Anat. Zürich	Ruge, 1891	..	..	17	..	..	..
"	Anat. Zürich	Ruge, 1891	..	..	18	..	..	..
"	Amsterdam	Kohlbrügge, 1891	13	4	17	5	4	33
"	M. Weber	Kohlbrügge, 1891	13	4	17	6	..	..
"	M. Weber	Kohlbrügge, 1891	12	5	17	5	..	..
"	Amsterdam	Kohlbrügge, 1891	13	5	18	4	..	..
"	Museum Leiden	Kohlbrügge, 1891	13	5	18	5	..	..
"	Munich	Ranke, 1897	13	4	17	4	..	..

TABLE VII

The Number of Vertebrae in the Different Spinal Regions in the Genus PONGO, Containing the Single Species Pongo Pygmaeus. All Specimens Have 7 Cervical Vertebrae

COLLECTION	OBSERVED BY	THORAC.	LUMBAR	THOR. L.	SACRAL	COCCYG.	TOTAL
Nat. M. 49857	Schultz	12	4	16	5	3	32
Nat. M. 49851	"	12	4	16	5	4	32
Nat. M. 49855	"	13	4	17	6	2	32
Nat. M. 49863	"	12	4	16	5	3	31
Nat. M. 49856	"	12	4	16	5	3	31
Nat. M. 49862	"	12	4	16	5	3	31
Nat. M. 49769	"	12	4	16	5	3	31
Nat. M. 49768	"	12	4	16	5	3	31
Nat. M. 153826	"	12	4	16	5	3	31
Nat. M. 153972	"	12	4	16	5	3	31
Nat. M. 49853	"	12	4	16	6	2	31
Nat. M. 49848	"	12	4	16	6	2	31
Nat. M. 49859	"	12	4	16	5	3	31
Nat. M. 153805	"	12	4	16	5	3	31
Nat. M. 145301	"	12	4	16	5	3	31
Nat. M. 153973	"	12	4	16	5	3	31
Nat. M. 49849	"	13	3	16	5	3	31
Nat. M. 145300	"	11½	3½	15	6	3	31
Nat. M. 145303	"	11	4	15	5	4	31
Nat. M. 145310	"	11	4	15	6	3	31
Nat. M. 143597	"	12	4	16	5	2	30
Nat. M. 22937	"	12	3	15	6	2	30
Nat. M. 153825	"	12	4	16	5	2	30
Nat. M. 49864	"	13	4	17	5	..	..
Nat. M. 153821	"	....	...	..	6	2	..
Nat. M. 153822	"	....	...	..	6	2	..
Nat. M. 153823	"	....	...	..	6	2	..
Nat. M. 49858	"	....	...	..	6	2	..
Nat. M 145309	"	....	...	..	5	3	..
Ph Acad. 11809	"	11	4	15	6	4	32
Ph. Acad. 11810	"	11½	3½	15	5	4	31
Ph. Acad.	"	12	4	16	5	2	30
Amer. M.	"	12½	3½	16	5	5	33
Amer. M.	"	11	4	15	5	3	30
Army M.	"	12	4	16	6	3	32
Zo. I. Z.	"	12	4	16	5	3	31
Zo. I. Z.	"	12	4	16	5	3	31
Zo. I. Z.	"	11½	3½	15	5	3	30
Harvard Mus. .	"	12	4	16	5	2	30
A. Jeff.	"	12	4	16	5	1	29
Field M.	"	12	4	16	4	2	29
M. a. c. P.	"	12	3	15	5	2	29
Wist. I.	"	....	...	..	4	..	..
Wist. I.	"	seven sacra with.....			5	..	..
Paris	Duvernoy, 1856	12	4	16	5	..	..
Paris	Broca, 1869	12	4	16	5	3	31
Genoa	Trinchese, 1870	11	5	16	5	2	30

TABLE VII (continued)

COLLECTION	OBSERVED BY	THORAC.	LUMBAR	THOR. L.	SACRAL	COCCYG.	TOTAL
.....	de Blainville (Bateson)	12	4	16	4	3	30
.....	Rosenberg, 1876	12	4	16	5	2	30
.....	Rosenberg, 1876	12	4	16	5	1	29
Roy. Coll. Surg.	Flower, 1884	12	4	16	5	4	32
Roy. Coll. Surg.	Flower, 1884	12	4	16	5	4	32
Roy. Coll. Surg.	Flower, 1884	12	4	16	5	3	31
Roy. Coll. Surg.	Flower, 1884	12	5	17	5	3	32
Roy. Coll. Surg.	Flower, 1884	11½	4½	16	5	3	31
.....	Westling, 1884	12	4	16	4	5	32
Dublin ..	Cunningham, 1886	12	4	16	8		31
.....	Paterson, 1893	12	5	17	5	3	32
.....	Paterson, 1893	12	5	17	5	..	..
.....	Paterson, 1893	12	5	17	4	..	..
.....	Paterson, 1893	12	4	16	5	3	31
.....	Paterson, 1893	12	4	16	5	3	31
.....	Paterson, 1893	12	4	16	5	3	31
.....	Paterson, 1893	12	4	16	5	..	..
.....	Paterson, 1893	12	4	16	5	..	..
.....	Paterson, 1893	11½	4½	16	5	..	..
.....	Paterson, 1893	12	4	16	4	..	..
.....	Paterson, 1893	11	5	16	4	4	31
.....	Paterson, 1893	12	4	16	4	3	30
.....	Paterson, 1893	12	4	16	4	3	30
Roy. Coll. Surg.	Bateson, 1894	11	5	16	5	2	30
Cambridge U. Mus.	Bateson, 1894	11	4	15	8		30
Leipzig ..	Fick, 1895	12	4	16	5	3	31
G. Max	Ranke, 1897	11	4	15	5	..	..
G. Max	Ranke, 1897	12	4	16	5	..	..
G. Max	Ranke, 1897	12	4	16	5	..	..
Univ. Munich	Ranke, 1897	12	4	16	5	..	..
Univ. Munich	Ranke, 1897	12	4	16	6	..	..
Univ. Munich	Ranke, 1897	13	3	16	6	..	..
Univ. Munich	Ranke, 1897	12	4	16	4	..	..
Univ. Munich	Ranke, 1897	13	4	17	5	..	..
Univ. Munich	Ranke, 1897	13	4	17	6	..	..
Amsterdam ..	Bolk, 1898	12	4	16	..	..	..
Amsterdam ..	Bolk, 1898	12	4	16	..	..	..
Columbia Univ.	Huntington, 1918	12	4	16	6	..	..
W. R. U. B 164	Todd, 1922	....	...	16	..	..	..
W. R. U. B 172	Todd, 1922	....	...	16	..	..	..
W. R. U. B 623	Todd, 1922	....	...	16	..	..	..
W. R. U. B 624	Todd, 1922	....	...	16	..	..	..
Cologne	Kempermann, 1929	11	4	15	6	..	..

TABLE VIII

The Number of Vertebrae in the Different Spinal Regions in the Genus PAN (Species Undetermined). All Specimens Have 7 Cervical Vertebrae

COLLECTION	OBSERVED BY	THORAC.	LUMBAR	THOR. L.	SACRAL	COCCYG.	TOTAL
A. Hopk. C 62	Schultz	13	4	17	6	4	34
Nat. M. 220062	"	14	3	17	6	4	34
Nat. M. 176230	"	13	4	17	6	3	33
Sch. 310	"	13	4	17	5	4	33
P. A. L. 9	"	13	4	17	6	3	33
P. A. L. 4	"	14	3	17	6	..	..
P. A. L.	"	13	4	17	..	..	..
Nat. M. 220065	"	13	4	17	5	3	32
Nat. M. 220327	"	12	5	17	6	2	32
Nat. M. 236971	"	12	4	16	6	3	32
Nat. M. 220326	"	12½	3½	16	6	3	32
Nat. M. 220063	"	13	3	16	6	..	..
Nat. M. 176226	"	....	...	..	6	2	..
Nat. M. 176227	"	....	...	..	6	..	..
Zo. I. Z.	"	13	4	17	6	2	32
M. a. c. P.	"	13	4	17	6	..	..
W. R. U. B 830	Straus	13	4	17	5	4	33
.....	Tyson, 1699	13	5	18	5	4	34
.....	Duvernoy, 1856	13	4	17	9		33
.....	Duvernoy, 1856	13½	3½	17	9		33
.....	Duvernoy, 1856	13	3	16	9		32
.....	Rosenberg, 1876	14	4	18	5	6	36
.....	Rosenberg, 1876	13	4	17	5	5	34
Roy. Coll. Surg.	Flower, 1884	13	4	17	5	..	..
Roy. Coll. Surg.	Flower, 1884	13	4	17	5	..	..
Roy. Coll. Surg.	Flower, 1884	13	4	17	5	..	..
Roy. Coll. Surg.	Flower, 1884	13	4	17	5	..	..
Roy. Coll. Surg.	Flower, 1884	13	4	17	8		32
Roy. Coll. Surg.	Flower, 1884	13	4	17	..	..	..
Roy. Coll. Surg.	Flower, 1884	12	4	16	5	5	33
Roy. Coll. Surg.	Flower, 1884	13	3	16	..	..	..
Dublin	Cunningham, 1886	13	4	17	10		34
Dublin	Cunningham, 1886	13	4	17	9		33
Dublin	Cunningham, 1886	13	4	17	8		32
.....	Paterson, 1893	14	4	18	5	4	34
.....	Paterson, 1893	13	4	17	5	4	33
.....	Paterson, 1893	13	4	17	5	3	32
.....	Paterson, 1893	13	4	17	6	2	32
.....	Paterson, 1893	13	4	17	6	2	32
.....	Paterson, 1893	13	4	17	6	..	..
.....	Paterson, 1893	13	4	17	5	2	31
.....	Paterson, 1893	14	3	17	6	2	32

TABLE VIII (continued)

COLLECTION	OBSERVED BY	THORAC.	LUMBAR	THOR. L.	SACRAL	COCCYG.	TOTAL
.....	Paterson, 1893	13	3	16	6	3	32
.....	Paterson, 1893	13	3	16	6	3	32
.....	Paterson, 1893	12	4	16	5	4	32
.....	Paterson, 1893	12	4	16	5	3	31
.....	Paterson, 1893	12	3	15	6	3	31
.....	Sperino, 1897	13	4	17	..	..	..
Univ. Munich	Ranke, 1897	13	4	17	5	..	..
Univ. Munich	Ranke, 1897	13	4	17	5	..	..
G. Max	Ranke, 1897	13	4	17	5	..	..
G. Max	Ranke, 1897	13	4	17	4	..	..
Amsterdam	Bolk, 1898	13	4	17	..	..	..
Amsterdam	Bolk, 1898	13	4	17	..	..	..
Columbia Univ.	Huntington, 1918	13	4	17	..	..	..
Columbia Univ.	Huntington, 1918	13	4	17	..	..	..
W. R. U. B 168	Todd, 1922	....	...	17	..	..	..
W. R. U. B 346	Todd, 1922	....	...	17	..	..	..
W. R. U. B 347	Todd, 1922	....	...	17	..	..	..
W. R. U. B 543	Todd, 1922	....	...	17	..	..	..
W. R. U. B 632	Todd, 1922	....	...	17	..	..	..
W. R. U. B 239	Todd, 1922	....	..	17	..	..	..
W. R. U. B 171	Todd, 1922	....	..	16	..	..	..
W. R. U. B 540	Todd, 1922	....	...	16	..	..	..
Cologne	Kempermann, 1929	12	5	17	4	..	..

TABLE IX

The Number of Vertebrae in the Different Spinal Regions in the Species GORILLA GORILLA. All Specimens Have 7 Cervical Vertebrae Except the Last Gorilla of Struthers, Which Has 8. In the Paper by Meyer the Number of Sacral Vertebrae Is Given as 2; However, in a Letter to the Author Professor Meyer States That This Is a Printer's Error and That the Sacrum Contained 5 Vertebrae. The Author Was Unable to Consult the Original Paper by Paterson So That He Is Not Absolutely Certain That None of His Specimens Have Been Used by Other Authors.

COLLECTION	OBSERVED BY	THORAC.	LUMBAR	THOR. L.	SACRAL	COCCYG.	TOTAL
P. A. L. 5	Schultz	13	4	17	6	5	35
P. A. L. 14	"	13	4	17	6	5	35
P. A. L. 8	"	13	4	17	6	3	33
P. A. L. 2	"	13	4	17	6	..	..
P. A. L. 3	"	13	4	17	6	..	..
P. A. L. 12	"	13	4	17	6	..	..
P. A. L. 13	"	13	4	17	5	4	33
P. A. L. 10	"	13	4	17	5	3	32
P. A. L. 6	"	13	4	17	5	2	32
P. A. L. 11	"	13	3	16	6	2	31
P. A. L. 1	"	12	4	16	6	..	..
Ph. Acad. 11805	"	13	4	17	6	3	33
Wist. I. 4491	"	13	4	17	6	3	33
Field M.	"	13	4	17	5	3	32
Field M.	"	13	4	17	5	3	32
Field M.	"	13	4	17	5	3	32
Field M.	"	14	3	17	5	3	32
Field M.	"	13	4	17	5	2	31
Zo. I. Z.	"	13	3	16	6	2	31
Nat. M. 154553	"	13	3	16	6	2	31
Nat. M. 176225	"	..	..	..	7	3	..
Nat. M. 174723	"	..	..	..	6	..	..
Nat. M. 174722	"	..	..	..	5	..	..
W. R. U. B 1057	Straus	13	3	16	6	..	..
W. R. U. B 169	"	13	3	16	5	..	..
.....	Duvernoy, 1856	13	4	17	5	..	..
.....	Duvernoy, 1856	13	3	16	11		34
Paris	Broca, 1869	13	4	17	5	4	33
Roy. Coll. Surg.	Flower, 1884	13	4	17	10		34
Roy. Coll. Surg.	Flower, 1884	13	4	17	5	4	33
Roy. Coll. Surg.	Flower, 1884	13	4	17	5	..	..
Roy. Coll. Surg.	Flower, 1884	13	4	17	5	..	..
Roy. Coll. Surg.	Flower, 1884	13	3	16	..	..	..
.....	Symington, 1890	13	3	16	6	4	33
.....	Eisler, 1892	13	4	17	..	..	..
.....	Paterson, 1893	13	4	17	5	..	..
.....	Paterson, 1893	13	4	17	5	..	..
.....	Paterson, 1893	13	4	17	6	..	..
.....	Paterson, 1893	14	3	17	5	4	33
.....	Paterson, 1893	13	3	16	6	4	33
.....	Paterson, 1893	13	3	16	6	4	33

TABLE IX (continued)

COLLECTION	OBSERVED BY	THORAC.	LUMBAR	THOR. L.	SACRAL	COCCYG.	TOTAL
....	Paterson, 1893	13	3	16	6	3	32
....	Paterson, 1893	13	3	16	6	2	31
....	Paterson, 1893	12	4	16	5	3	31
....	Paterson, 1893	13	3	16	5	2	30
....	Paterson, 1893	12	3	15	6	..	..
Jardin des Plantes	Struthers, 1893	13	4	17	..	..	..
Jardin des Plantes	Struthers, 1893	13	4	17	..	..	..
British Museum	Struthers, 1893	13	4	17	..	..	..
Roy Coll. Surg. (not used by Flower)	Struthers, 1893	14	3	17	..	..	..
Anthrop. I. London	Struthers, 1893	13	4	17	..	..	..
Publ. Mus. Vienna	Struthers, 1893	13	4	17	..	..	..
....	Struthers, 1893	13	4	17	..	..	..
Publ. Mus. Basel	Struthers, 1893	14	3	17	..	..	..
Louvain	Struthers, 1893	13	4	17	..	..	..
Mac Gill, Montreal	Struthers, 1893	13	4	17	..	..	..
Harvard University	Struthers, 1893	13	4	17	..	..	..
Univ. Mus. Glasgow	Struthers, 1893	14	3	17	..	..	..
Edinburgh	Struthers, 1893	13	4	17	..	..	..
Edinburgh	Struthers, 1893	13	4	17	..	..	..
..	Struthers, 1893	13	4	17	..	..	..
Aberdeen	Struthers, 1893	13	4	17	..	..	..
Aberdeen	Struthers, 1893	13	3	16	..	..	..
Univ. Cambridge	Bateson, 1894	12	4	16	5	3	31
Munich	Ranke, 1897	14	3	17	6	..	..
Munich	Ranke, 1897	13	4	17	5	..	..
Munich	Ranke, 1897	13	4	17	5	..	..
G. Max	Ranke, 1897	13	4	17	5	..	..
G. Max	Ranke, 1897	13	3	16	6	..	..
Munich	Ranke, 1897	13	3	16	6	..	..
Munich	Ranke, 1897	13	3	16	6	..	..
Munich	Ranke, 1897	13	3	16	5	..	..
Munich	Ranke, 1897	13	3	16	5	..	..
Amsterdam ...	Bolk, 1898	13	5	18	..	..	..
Amsterdam ...	Bolk, 1898	13	3	16	..	..	..
Leland Stanford	Meyer, 1915	13	3	16	5	3	31
Columbia Univ.	Huntington, 1918	13	3	16	6	..	..
W. R. U. B 168	Todd, 1922	..	..	17	..	..	..
W. R. U. B 624	Todd, 1922	..	..	17	..	..	..
W. R. U. B 626	Todd, 1922	..	..	16	..	..	..
W. R. U. B 627	Todd, 1922	..	..	16	..	..	..
Cologne ..	Kempermann, 1929	13	4	17	..	..	..

TABLE X

The Number of Vertebrae in the Different Spinal Regions in the Species GORILLA BERINGEI. All Specimens Have 7 Cervical Vertebrae

COLLECTION	OBSERVED BY	THORAC.	LUMBAR	THOR. L.	SACRAL	COCCYG.	TOTAL
P. A. L. 7	Schultz	12	4	16	5	4	32
Nat. M. 239883	"	12	4	16	6	3	32
Nat. M. 239884	"	13	3	16	5	..	..
Amer. M. 54090	"	13	3	16	6	3	32
Amer. M. 54092	"	12	4	16	6	..	..
Amer. M. 54091	"	13	3	16	6	2	31
Amer. M. 54089	"	13	3	16	6	..	..

TABLE XI

The Proportions of the STERNUM of Primates. The Specimens of the Same Species and Sex Are Grouped According to the Increasing Length of the Sternum without the Xyphoid Process (This Length Is Given in Mm.). The Averages of These Proportions Are Listed in Table 14.

SPECIES	SEX	AGE	COLLECTION	MANUBRIUM + CORPUS LENGTH	MANUBRIUM LENGTH / CORPUS LENGTH	MANUBRIUM BREADTH / MANUBRIUM LENGTH	CORPUS BREADTH / CORPUS LENGTH
Galago spec.?	?	adult	Nat. M. 49548	28.8	38.4	86.3	14.4
Cebus capucinus	♂	"	Sch. 852	74	29.8	94.2	15.8
Ateles geoffroyi	♀	"	Sch. 819	66	26.9	164.2	17.3
Pithecus rhesus	♂	juv.	Sch. 149	49	40.0	107.1	14.3
" "	♂	adult	Sch. 333	82	36.7	104.5	13.3
Pygathrix potenziani	♂	"	Nat. M. 49658	75	36.4	105.0	14.5
Hylobates concolor	♀	adult	Nat. M. 154373	48	54.8	182.2	51.6
" "	♂	"	Nat. M. 151835	52	62.5	150.0	37.5
" "	♂	"	Nat. M. 153798	53	51.4	155.5	31.4
" "	♀	"	Nat. M. 198840	54	50.0	144.5	41.7
" "	♀	"	Nat. M. 153799	59	47.5	147.3	27.5
" "	♀	"	Nat. M. 151833	60	46.3	168.4	34.1
" *leuciscus*	♂	"	Nat. M. 156296	41	57.9	146.5	38.4
" "	♂	"	Nat. M. 154722	55	44.7	170.5	50.0
" *agilis*	♂	"	Nat. M. 49697	61	56.4	145.5	43.6
" "	♂	"	Nat. M. 49694	63	61.6	141.6	35.9
" *lar*	♂	"	Sch. 907	57	58.3	138.0	44.8
" spec.?	?	"	Nat. M. 240495	67	31.4	162.4	27.4
Symphalangus klossi	♂	adult	Nat. M. 49656	45	73.1	136.8	50.0
" "	♀	"	Nat. M. 49657	50	47.1	162.4	38.2
Symphalangus syndact.	♀	adult	Nat. M. 49748	53	82.8	137.5	55.2
" "	♂	"	Nat. M. 49746	61	84.9	146.3	48.5
" "	♂	"	Sch. 130	61	79.4	122.2	55.9
Pongo pygmaeus	♂	inf.	Nat. M. 49849	59	51.3	140.0	56.4
" "	♀	"	Nat. M. 49435	62	44.2	136.7	48.8
" "	♂	"	Nat. M. 49856	66	61.0	136.0	58.5
" "	♀	juv.	Nat. M. 145303	75	47.1	133.3	58.8
" "	♀	"	Nat. M. 153821	75	50.0	136.0	64.0
" "	♀	"	Nat. M. 49863	83	48.2	140.7	55.4
" "	♂	"	Wist. I. 2223	100	66.7	107.4	66.7
" "	♀	adult	Nat. M. 49848	73	69.7	186.6	76.8
" "	♀	"	Wist. I. 2170	83	53.7	151.7	59.3
" "	♀	"	Nat. M. 49769	84	82.6	136.8	65.2
" "	♀	"	Wist. I. 2172	86	59.3	121.8	79.6
" "	♀	"	Nat. M. 49857	91	42.2	137.0	46.8
" "	♀	"	Nat. M. 49853	91	49.2	150.0	54.1
" "	♀	"	Nat. M. 145300	93	63.1	141.6	56.1

TABLE XI (continued)

SPECIES	SEX	AGE	COLLECTION	MANUBRIUM + CORPUS LENGTH	MANUBRIUM LENGTH / CORPUS LENGTH	MANUBRIUM BREADTH / MANUBRIUM LENGTH	CORPUS BREADTH / CORPUS LENGTH
Pongo pygmæus	♀	adult	Nat. M. 49862	94	44.6	144.7	40.0
" "	♀	"	Nat. M. 153805	94	54.1	130.2	55.7
" "	♀	"	Wist. I. 2222	94	77.3	104.8	71.7
" "	♀	"	Nat. M. 49851	95	55.7	141.1	55.7
" "	♀	"	Nat. M. 22937	97	49.3	153.0	49.3
" "	♀	"	Nat. M. 145302	97	61.7	140.5	60.0
" "	♀	"	Ph. Acad. 12597	98	60.7	129.6	54.1
" "	♀	"	Nat. M. 145309	110	57.1	120.0	45.7
" "	♀	"	Nat. M. 49768	110	54.9	141.0	57.7
" "	♀	"	Nat. M. 145304	131	52.3	135.5	54.7
" "	♂	"	Nat. M. 49860	104	48.6	158.7	60.0
" "	♂	"	Nat. M. 145305	115	53.2	162.4	58.7
" "	♂	"	Nat. M. 49864	117	42.7	122.8	42.7
" "	♂	"	Wist. I. 7120	118	49.4	117.9	55.7
" "	♂	"	Nat. M. 145310	119	56.6	130.1	54.0
" "	♂	"	Nat. M. 49858	119	91.9	117.5	74.2
" "	♂	"	Nat. M. 49859	125	58.2	123.8	54.4
" "	♂	"	Nat. M. 153823	129	38.7	163.8	54.9
" "	♂	"	Wist. I. 2168	130	60.5	128.5	53.1
" "	♂	"	Nat. M. 49855	137	55.7	116.2	56.8
Pan spec.?	♀	adult	Nat. M. 176226	110	50.7	132.4	21.9
" "	♀	"	Nat. M. 176227	117	44.4	127.7	22.2
" "	♀	"	P. A. L. 9	119	33.7	159.8	20.2
" "	♂	"	Nat. M. 176230	132	51.7	128.8	23.0
" "	♂	"	Nat. M. 220326	157	33.0	194.7	19.5
Gorilla gorilla	♀	inf.	P. A. L. 5	84	58.5	119.3	33.7
" "	♀	adult	P. A. L. 6	135	75.3	106.8	44.2
" "	♀	"	P. A. L. 14	148	52.6	115.6	40.4
" "	♀	"	P. A. L. 2	161	52.9	133.8	41.2
" "	♂	juv.	P. A. L. 10	126	65.8	128.0	39.5
" "	♂	adult	P. A. L. 11	162	70.5	129.7	63.2
" "	♂	"	Nat. M. 174723	171	52.6	149.0	43.7
" "	♂	"	Wist. I. 4491	174	64.1	139.6	46.2
" "	♂	"	Ph. Acad. 11805	189	71.8	131.6	58.2
" "	♂	"	P. A. L. 12	212	55.9	136.9	41.1
" "	♂	"	P. A. L. 13	214	56.2	135.1	38.7
" "	♂	"	P. A. L. 8	247	47.0	131.7	35.7
" *beringei*	♀	juv.	P. A. L. 7	141	62.1	112.9	39.1
" "	♀	adult	Amer. M. 54091	157	72.5	142.3	57.1
" "	♀	"	Amer. M. 54092	183	59.1	135.2	42.6
" "	♂	"	Amer. M. 54090	196	79.7	125.3	52.3
" "	♂	"	Amer. M. 54089	209	50.3	138.5	46.7
" "	♂	"	Nat. M. 239883	221	61.3	119.0	39.4

TABLE XI (continued)

SPECIES	SEX	AGE	COLLECTION	MANUBRIUM + CORPUS LENGTH	MANUBRIUM LENGTH / CORPUS LENGTH	MANUBRIUM BREADTH / MANUBRIUM LENGTH	CORPUS BREADTH / CORPUS LENGTH
Homo (Negro)	♂	adult	A. Hopk...	141	48.4	126.0	49.5
" "	♂	"	A. Hopk...	146	50.5	106.0	31.9
" "	♂	"	P. A. L...	196	46.3	117.7	44.8
" (Chinese)	♂	"	P. A. L...	136	44.7	161.7	34.0
" (White)	♂	"	A. Hopk...	142	46.4	124.3	41.2
" "	♂	"	A. Hopk...	150	41.5	118.1	31.1
" "	♂	"	A. Hopk...	156	45.8	126.4	34.6

TABLE XII

***The Absolute Length** (in Mm.) of the CLAVICLE and Two Clavicular Proportions in Gorillas. The First Proportion Gives the Circumference of the Middle of the Clavicle in Percentage of the Length of the Clavicle, the Second Proportion Gives the Length of the Clavicle in Percentage of the Length of the Humerus.*

SPECIES	SEX	AGE	COLLECTION	LENGTH OF CLAVICLE	CIRCUMFER. OF CLAVIC. / CLAVICLE L.	CLAVICLE L. / HUMERUS L.
Gorilla gorilla	♀	inf.	P. A. L. 5	81	28.4	39.1
" "	♂	"	P. A. L. 3	98	26.5	35.5
Gorilla gorilla	♂	juv.	P. A. L. 10	129	26.3	35.5
" "	♀	adult	Nat. M. 154553	130	31.5	32.7
" "	♀	"	P. A. L. 14	136	25.7	36.3
" "	♀	"	P. A. L. 2	137	26.3	38.4
" "	♀	"	P. A. L. 6	143	25.9	39.2
" "	♂	"	Wist. I. 4491	148	32.4	35.9
" "	♂	"	P. A. L. 11	151	30.4	36.7
" "	♂	"	Nat. M. 174722	153	29.4	38.3
" "	♂	"	Ph. Acad. 5530	153	24.8	37.7
" "	♂	"	Ph. Acad. 11805	154	32.5	35.7
" "	♂	"	P. A. L. 1	156	30.8	36.8
" "	♂	"	Nat. M. 174723	157	24.8	39.0
" "	♂	"	P. A. L. 12	169	27.2	38.2
" "	♂	"	P. A. L. 13	174	25.8	38.9
" "	♂	"	P. A. L. 8	177	25.4	36.9
Gorilla beringei	♂	inf.	Nat. M. 239884	77	24.7	40.9
Gorilla beringei	♀	juv.	P. A. L. 7	140	25.0	43.0
" "	♀	adult	Amer. M. 54091	144.5	....	42.0
" "	♀	"	Amer. M. 54092	157	....	43.4
" "	♂	"	Amer. M. 54090	172	....	44.1
" "	♂	"	Amer. M. 54089	179.5	....	43.6
" "	♂	"	Nat. M. 239883	190	25.2	43.7

TABLE XIII

The Morphological Length (in Mm.), Some Proportions, and the Azillo-spinal Angle (in Degrees) of the SCAPULA of Primates. All Specimens Are Adult, Except the First Gorilla Gorilla and the First Gorilla Beringei Which Are Juvenile or Subadult. The Averages of the Figures in This Table Are Given in Table 16.

SPECIES	SEX	COLLECTION	MORPHOLOG. LENGTH	MORPHOLOG. LENGTH / FOSSA INFRASPINATA + SUPRASPINATA BR.	FOSSA SUPRASPIN. BR. / FOSSA INFRASPIN. BR.	FOSSA INFRASPIN. BR. / MORPHOLOG. LENGTH	FOSSA SUPRASPIN. BR. / MORPHOLOG. LENGTH	SPINE LENGTH / MORPHOLOG. LENGTH	ACROMION BREADTH / SPINE LENGTH	AXILLO-SPINAL ANGLE
Cebus capucinus	♂	Sch. 608	45	102.2	25.7	77.8	20.0	122.1	12.2	34
Alouatta palliata.....	♂	Sch. 607	60	77.9	45.3	88.3	40.0	123.2	12.1	38
Ateles geoffroyi	♀	Sch. 819	55	87.3	50.0	76.4	38.2	123.5	10.3	26
Pithecus rhesus	♂	Sch. 333	74	105.6	45.8	64.9	29.7	118.8	13.6	28
Papio tessellatus.....	♂	Nat. M. 239743	117	142.7	32.3	53.0	17.1	113.7	9.8	30
Pygathrix potenziani	♂	Nat. M. 49658	47	81.1	23.4	100.0	23.4	119.0	10.7	36
Hylobates concolor	♀	Nat. M. 198840	61	141.8	65.4	42.6	27.9	118.0	15.3	19
" "	♀	Nat. M. 154371	64	139.0	64.3	43.7	28.1	124.9	13.8	18
" "	♀	Nat. M. 153799	66	132.0	92.3	39.4	36.3	125.7	13.3	15
" "	♂	Nat. M. 151835	54	110.2	58.1	57.4	33.3	131.4	14.1	20
" "	♂	Nat. M. 151837	58	113.7	75.9	50.0	37.9	127.5	12.2	19
" "	♂	Nat. M. 151832	59	125.5	80.8	44.1	35.6	123.7	13.7	17
" *agilis*	♂	Nat. M. 49694	65	116.0	86.7	46.1	40.0	127.6	16.9	16
" "	♂	Nat. M. 49697	67	113.5	73.5	50.7	37.3	126.8	15.3	20
" *leuciscus*	♂	Nat. M. 154722	67	152.1	100.0	32.8	32.8	125.3	13.1	11
" *lar*	♂	Sch. 907	63	140.0	95.7	36.5	34.9	126.8	11.2	14
Symphalangus klossi	♀	Nat. M. 49657	53	110.3	60.0	56.6	34.0	130.0	13.0	20
" "	♂	Nat. M. 49656	55	110.0	61.3	56.3	34.5	125.4	14.5	20
Symphalangus syndact.	♀	Nat. M. 49747	67	97.1	81.6	56.7	46.3	135.7	16.5	20
" "	♀	Nat. M. 49748	77	130.4	90.3	40.3	36.3	124.7	14.6	13
" "	♂	Sch. 130	73	123.7	84.4	43.8	37.0	123.1	15.6	13
" "	♂	Nat. M. 49746	81	115.7	79.5	48.1	38.3	132.1	16.8	15
Pongo pygmaeus	♀	Nat. M. 153805	81	71.7	24.2	112.3	27.3	133.4	14.8	37
" "	♂	Nat. M. 145301	117	66.5	26.6	118.8	31.6	135.0	12.0	42
Pan spec.?	♀	P. A. L. 9	90	77.6	70.6	75.6	53.3	140.0	15.9	24
" "	♂	Nat. M. 220326	114	88.4	84.3	61.4	51.7	129.0	12.2	21
Gorilla gorilla	♂	P. A. L. 10	123	78.3	57.0	81.4	46.3	136.5	17.3	30
" "	♀	P. A. L. 14	125	74.0	60.9	84.0	51.2	140.0	14.9	31
" "	♀	P. A. L. 2	125	78.6	67.4	76.0	51.2	140.8	17.0	27
" "	♀	P. A. L. 6	130	92.9	66.7	64.6	43.0	140.0	14.8	24
" "	♂	P. A. L. 1	161	78.1	64.8	77.7	50.3	134.1	14.4	30
" "	♂	P. A. L. 11	161	70.6	60.5	88.2	53.4	140.3	18.6	34
" "	♂	P. A. L. 13	169	68.7	59.7	91.2	54.4	134.9	17.1	34
" "	♂	P. A. L. 12	173	75.5	64.7	80.4	52.0	139.3	19.1	32

TABLE XIII (continued)

SPECIES	SEX	COLLECTION	MORPHOLOG. LENGTH	MORPHOLOG. LENGTH / FOSSA INFRASPINATA + SUPRASPINATA BR.	FOSSA SUPRASPIN. BR. / FOSSA INFRASPIN. BR.	FOSSA INFRASPIN. BR. / MORPHOLOG. LENGTH	FOSSA SUPRASPIN. BR. / MORPHOLOG. LENGTH	SPINE LENGTH / MORPHOLOG. LENGTH	ACROMION BREADTH / SPINE LENGTH	AXILLO-SPINAL ANGLE
Gorilla gorilla	♂	P. A. L. 8	185	72.3	65.2	83.8	54.6	139.4	18.6	34
" *beringei*	♀	P. A. L. 7	112	67.5	61.1	92.0	56.2	149.1	18.6	32
" "	♂	Nat. M. 239883	170	73.6	54.0	88.3	47.6	140.5	18.0	33
Homo (Negro)	♀	P. A. L. ..	83	65.3	41.1	108.3	44.6	150.6	21.6	40
" "	♀	P. A. L. ..	97	69.7	44.8	99.0	44.3	137.2	15.8	38
" "	♀	P. A. L. ..	99	75.0	43.5	92.9	40.4	130.4	18.6	44
" "	♂	A. Hopk. ..	98	61.2	39.1	117.3	45.9	142.9	22.8	49
" "	♂	P. A. L. ..	100	66.2	42.4	106.0	45.0	140.0	17.8	44
" "	♂	Sch.	102	63.0	38.5	114.7	44.1	142.1	19.3	47
" "	♂	P. A. L. ..	103	56.9	34.0	131.0	44.6	139.8	19.4	50
" "	♂	P. A. L. ..	105	58.7	43.2	119.0	51.4	143.8	18.5	51
" "	♂	Sch. ..	105	62.2	36.3	118.0	42.9	140.0	21.8	50
" "	♂	A. Hopk. ..	106	62.4	47.8	108.4	51.9	137.7	21.2	46
" "	♂	P. A. L. ..	107	67.3	42.0	104.6	43.9	129.0	17.4	42
" "	♂	Sch.	108	62.5	38.4	115.7	44.4	135.2	21.2	53
" "	♂	A. Hopk. ..	111	74.5	28.4	104.5	29.7	131.5	19.9	49
" "	♂	A. Hopk. ..	112	67.9	42.2	103.5	43.7	133.0	18.8	42
" "	♂	A. Hopk. ..	112	70.9	41.1	100.0	41.1	135.7	17.8	46
" "	♂	P. A. L. ...	118	73.7	45.4	93.2	42.4	134.7	19.5	37
" (White)	♀	P. A. L. ...	85	64.9	37.9	111.7	42.3	140.0	18.5	55
" "	♀	P. A. L. ...	86	59.3	40.8	119.8	48.8	136.1	17.9	48
" "	♀	Sch.	90	63.3	42.0	111.0	46.7	134.5	20.6	53
" "	♂	A. Hopk. ..	88	59.8	36.1	122.7	44.3	140.9	18.5	50
" "	♂	P. A. L. ...	95	56.2	36.3	130.5	47.4	137.9	22.1	58
" "	♂	P. A. L. ...	97	57.7	25.4	138.1	35.1	139.2	22.2	57
" "	♂	A. Hopk. ..	105	62.1	36.3	118.1	42.8	133.3	17.8	55
" "	♂	A. Hopk. ..	106	65.9	40.0	108.5	43.4	133.0	19.8	48
" "	♂	P. A. L. ...	106	65.1	41.7	108.5	45.3	137.7	18.5	45
" "	♂	Sch.	109	65.3	41.5	108.2	44.9	138.5	20.5	44
" "	♂	A. Hopk. ..	110	71.4	46.7	95.5	44.5	132.7	16.4	38
" "	♂	P. A. L. ...	116	68.7	50.9	96.6	49.1	142.2	18.2	40

TABLE XIV

The Ilium Length (in Mm.) and Some Proportions of the PELVIS of Primates. The Averages of the Figures in This Table Are Given in Table 17

SPECIES	SEX	AGE	COLLECTION	ILIUM LENGTH	ILIUM LENGTH / ISCHIUM LENGTH	PUBIS LENGTH / ISCHIUM LENGTH	ILIUM WIDTH / ILIUM LENGTH	FOSSA IL. WIDTH / SACRAL SURF. W.	FOSSA IL. DEPTH / FOSSA IL. WIDTH
Oedipomidas geoffroyi	♂	Adult	Sch. 903	30	166.7	83.4	40.0	2.5	0
Saimiri örstedii	♂	"	Sch. 865	35	147.8	66.7	33.8	3.8	0
Cebus capucinus	♂	"	Sch. 852	63	185.2	79.4	39.7	33.3	0
Cebus capucinus	♂	"	Sch. 841	64	182.7	82.9	35.9	31.6	0
Alouatta palliata	♂	"	Sch. 607	80	222.1	111.0	37.5	146.6	+ 9.1
Ateles geoffroyi	♀	"	Sch. 819	100	227.0	102.2	42.0	152.5	− 3.4
Pithecus rhesus	♀	infant	Sch. 209	56	200.0	67.9	35.7	61.5	0
" "	♂	juv.	Sch. 149	75	208.2	80.5	41.3	83.3	0
" "	♀	adult	Sch. ..	85	197.5	100.0	36.5	72.3	+ 7.7
" "	♂	"	Sch. 333	95	211.0	82.2	37.9	89.5	+20.6
Papio tessellatus	♂	"	Nat. M. 239743	127	208.3	83.6	48.0	120.6	+ 5.7
Hylobates concolor	♀	adult	Nat. M. 198840	77	220.0	108.5	58.4	235.7	0
" "	♀	"	Nat. M. 154372	84	221.0	105.2	57.1	226.7	− 2.9
" "	♀	"	Nat. M. 153797	86	220.3	89.7	55.8	220.0	− 6.1
" "	♀	"	Nat. M. 154371	89	240.3	97.3	41.6	192.9	0
" "	♀	"	Nat. M. 154373	89	247.1	100.0	47.2	223.1	+ 6.9
" "	♀	"	Nat. M. 151833	89	217.1	100.0	59.5	271.2	− 5.3
" "	♀	"	Nat. M. 153801	93	226.7	92.7	58.1	293.0	− 4.9
" "	♀	"	Nat. M. 153799	95	237.3	87.5	51.6	260.0	− 7.7
" "	♂	"	Nat. M. 151837	85	236.0	100.0	44.7	207.1	− 3.5
" "	♂	"	Nat. M. 154370	85	229.5	89.2	54.1	228.4	− 3.1
" "	♂	"	Nat. M. 151832	85	242.6	100.0	52.9	193.7	−16.1
" "	♂	"	Nat. M. 153798	86	215.0	85.0	45.3	221.2	+ 6.5
" "	♂	"	Nat. M. 151835	87	241.3	97.2	50.5	214.2	−13.3
" "	♂	"	Nat. M. 151834	92	224.2	90.2	54.3	250.0	−11.4
" *agilis*	♂	"	Nat. M. 49698	82	210.2	89.7	54.9	221.2	0
" "	♂	"	Nat. M. 49694	94	234.8	100.0	44.7	166.5	− 2.0
" "	♂	"	Nat. M. 49697	96	213.2	80.0	54.2	188.8	− 8.8
" *leuciscus*	♀	juv.	Sch. 802	62	221.2	82.2	45.1	174.9	0
" "	♂	"	Nat. M. 156296	74	264.0	92.9	47.3	260.0	− 3.8
" "	♂	adult	Nat. M. 154722	97	242.2	90.0	47.4	242.7	− 5.9
" *lar*	♂	"	Sch. 907	82	215.7	86.9	41.4	200.0	− 8.3
" "	♂	"	Nat. M. 49463	94	235.0	95.0	53.2	212.2	−17.6
" spec.?	?	"	Nat. M. 240495	94	261.0	116.6	51.0	250.0	0
Symphalangus klossi	♀	adult	Nat. M. 49657	85	223.7	100.0	62.3	307.5	−12.5
" "	♂	"	Nat. M. 49656	84	221.0	89.5	57.2	257.1	−11.1
Symphalangus syndact.	♀	adult	Nat. M. 49747	104	242.0	113.9	66.3	283.2	− 5.9
" "	♀	"	Nat. M. 49748	107	248.9	113.8	60.8	250.0	−11.1
" "	♂	"	Sch. 130	104	266.7	115.3	62.5	300.0	− 8.3
" "	♂	"	Nat. M. 49746	120	250.0	104.1	58.3	279.0	−11.3

TABLE XIV (continued)

SPECIES	SEX	AGE	COLLECTION	ILIUM LENGTH	ILIUM LENGTH / ISCHIUM LENGTH	PUBIS LENGTH / ISCHIUM LENGTH	ILIUM WIDTH / ILIUM LENGTH	FOSSA IL. WIDTH / SACRAL SURF. W.	FOSSA IL. DEPTH / FOSSA IL. WIDTH
Pongo pygmaeus	♂	juv.	Nat. M. 49849	106	200.0	77.4	63.2	240.0	− 6.2
" "	♀	adult	Nat. M. 153805	137	185.2	94.5	77.4	254.2	− 4.8
" "	♂	"	Nat. M. 145301	177	194.6	103.2	77.4	281.8	− 9.3
Pan spec.?	♀	infant	P. A. L. 4	85	197.5	60.5	50.6	235.7	0
" "	♂	juv.	Sch. 310	108	196.5	69.1	58.3	235.0	+ 1.5
" "	♀	adult	P. A. L. 9	165	198.8	83.2	57.5	303.5	+ 1.3
" "	♂	"	Nat. M. 220326	182	200.0	80.2	67.0	306.2	−10.5
Gorilla gorilla	♀	infant	P. A. L. 5	105	184.2	80.7	79.0	320.8	− 4.9
" "	♂	juv.	P. A. L. 3	136	174.4	73.1	81.7	327.6	− 7.3
" "	♀	adult	P. A. L. 2	191	189.0	97.0	90.7	388.3	−17.4
" "	♀	"	P. A. L. 14	194	204.2	99.0	93.3	417.4	−13.4
" "	♀	"	P. A. L. 6	204	194.3	91.4	83.8	476.8	− 7.7
" "	♂	juv.	P. A. L. 10	202	208.2	96.9	78.7	329.0	− 9.6
" "	♂	adult	P. A. L. 1	216	167.3	88.4	89.8	425.1	−19.6
" "	♂	"	P. A. L. 13	232	182.6	100.0	92.7	364.5	−17.1
" "	♂	"	P. A. L. 12	233	175.0	91.0	94.0	423.5	−15.7
" "	♂	"	P. A. L. 11	234	190.2	100.8	94.0	358.7	−19.4
" "	♂	"	P. A. L. 8	238	164.0	91.1	90.3	361.0	−15.1
Gorilla beringei	♂	infant	Nat. M. 239884	108	200.0	81.5	75.9	280.8	− 6.8
" "	♀	juv.	P. A. L. 7	196	186.6	89.5	83.2	297.6	−16.8
" "	♀	adult	Amer. M. 54091	220	203.5	108.3	86.4	375.7	−13.6
" "	♀	"	Amer. M. 54092	231	204.3	115.0	82.7	283.0	−19.3
" "	♂	"	Nat. M. 239883	260	192.5	95.6	87.3	358.0	−16.2
" "	♂	"	Amer. M. 54090	261	196.2	108.2	89.3	415.9	−15.3
" "	♂	"	Amer. M. 54089	268	190.0	95.1	87.0	385.3	−13.5
Homo (White)	♂	fetus	P. A. L. ..	26	162.4	93.8	111.5	113.2	− 5.9
" (Negro)	♂	fetus	P. A. L. ..	31	155.0	95.0	112.8	125.0	− 8.0
" (Negro)	♀	newborn	P. A. L. ..	37	148.0	92.1	116.1	114.2	− 8.3
" (Negro)	♀	newborn	P. A. L. ..	41	146.3	89.3	112.1	130.0	− 7.7
Homo (Negro)	♀	adult	P. A. L. ..	124	149.4	100.0	122.6	137.5	−12.5
" "	♀	"	P. A. L. ..	124	149.4	96.4	121.0	186.6	−10.1
" "	♂	"	Sch.	117	130.0	84.4	124.7	142.3	−11.9
" "	♂	"	Sch.	120	125.0	91.6	127.5	125.3	−16.7
" "	♂	"	Sch.	127	145.9	79.3	109.5	149.0	− 7.6
" "	♂	"	A. Hopk. ..	129	137.2	93.6	124.8	157.8	−17.3
" "	♂	"	Sch.	131	137.9	90.6	126.7	158.5	−11.6
" "	♂	"	P. A. L. ..	131	135.0	80.5	117.5	155.0	−10.0
" "	♂	"	P. A. L. ..	145	151.0	88.5	120.0	134.7	−15.8
" (White)	♀	"	A. Hopk. ..	118	142.1	95.1	127.1	161.2	−12.0
" "	♀	"	P. A. L. ..	125	152.4	100.0	120.8	190.0	−12.4
" "	♂	"	P. A. L. ..	121	133.0	83.5	121.5	131.5	−13.9
" "	♂	"	P. A. L. ..	122	128.4	88.4	117.2	162.8	−19.3
" "	♂	"	P. A. L. ..	132	137.5	75.0	118.2	146.7	−13.2
" "	♂	"	Sch.	139	131.0	92.4	124.4	145.4	−17.2

TABLE XV

The Limb Proportions of Adult LOWER PRIMATES Measured by the Author

SPECIES	SEX	COLLECTION	HUMERUS LENGTH	BRACHIAL INDEX	CRURAL INDEX	INTER-MEMBRAL INDEX
Lemur mongoz	?	Nat. M. 4994	74.2	102.2	97.1	70.5
Galago spec.?	?	Nat. M. 49548	40.4	105.2	91.5	64.9
Saimiri örstedii	♂	Sch. 865	73.0	91.8	98.0	79.5
Cebus albifrons	♂	Nat. M. 24948	97.5	91.8	102.5	79.6
Cebus capucinus	♂	Sch. 608	101.8	94.2	93.0	78.4
Cebus capucinus	♂	Sch. 852	110	97.3	98.5	79.8
Cebus capucinus	♂	Sch. 837	113	98.3	95.2	79.2
Cebus capucinus	♂	Sch. 841	118	97.5	96.0	80.4
Alouatta palliata	♂	Sch. 541	151	96.1	88.8	103.8
Alouatta palliata	♂	Sch. 607	154	92.9	88.2	103.8
Alouatta seniculus	♂	Sch. 763	176	88.6	91.7	97.4
Ateles geoffroyi	♀	Sch. 819	196	100.4	94.2	93.9
Pithecus rhesus	♀	P. A. L. 16	131	97.7	94.0	85.4
Pithecus rhesus	♀	P. A. L. 17	136	99.5	90.4	85.9
Pithecus rhesus	♂	Sch. 333	143	100.7	98.2	87.2
Pithecus philippinensis	♀	P. A. L. 19	118	97.5	93.0	94.3
Papio tessellatus	♂	Nat. M. 239743	218	110.1	88.2	95.9
Nasalis larvatus	♀	Wist. I. 661	156	100.6	92.2	91.0
Nasalis larvatus	♀	Wist. I. 668	172	102.8	89.6	96.5
Nasalis larvatus	♂	Wist. I. 4750	205	107.2	87.8	95.7
Nasalis larvatus	♂	Wist. I. 6101	223	98.2	86.0	92.5
Pygathrix potenziani	♂	Nat. M. 49658	130	106.8	89.7	81.0
Colobus abyssinicus	♀	Amer. M. 52223	147	91.2	91.4	78.5
Colobus angolensis	♂	Amer. M. 52149	163	97.5	93.3	79.7

TABLE XVI

The Limb Proportions in the Family HYLOBATIDAE

SPECIES	AGE	SEX	COLLECTION	MEASURED BY	HUMERUS LENGTH	BRACHIAL INDEX	CRURAL INDEX	INTERMEMBRAL INDEX
Hylobates lar	juv.	♂	.....	Mollison, 1911	104	99.0	83.0	119.0
" "	adult	♀	Zo. I. Z. 130	Schultz	224	116.0	91.7	131.5
" "	adult	♂	Sch. 907	"	219	115.9	85.9	129.2
" "	adult	♂	.....	Mollison, 1911	228	113.0	87.0	132.0
" "	adult	♂	.....	Mollison, 1911	230	109.0	92.0	136.0
" "	adult	♂	Zo. I. Z. 48	Schultz	230	117.3	86.3	136.9
" "	adult	?	.....	Duvernoy, 1856	232	112.0	89.3	132.5
" "	adult	♂	Nat. M. 49463	Schultz	237	110.5	88.6	130.9
" *pileatus*	juv.	♂	A. Hopk. 128	"	156	102.2	90.1	117.7
" "	juv.	♀	A. Hopk. 131	"	170	107.0	89.3	117.7
" "	adult	♀	A. Hopk. 124	"	221	113.1	89.2	122.6
" "	adult	♀	A. Hopk. 133	"	222	112.1	87.8	122.9
" "	adult	♀	A. Hopk. 125	"	225	109.5	89.3	127.3
" "	adult	♀	A. Hopk. 129	"	227	108.3	89.7	122.8
" "	adult	♀	A. Hopk. 126	"	232	113.8	89.7	123.3
" "	adult	♀	A. Hopk. 127	"	238	112.1	89.7	124.3
" *leucisacus*	juv.	♀	Sch. 802	"	160	108.7	86.4	128.0
" "	juv.	♂	Nat. M. 156296	"	191	100.5	84.6	118.5
" "	adult	?	.....	Mollison, 1911	231	115.0	85.0	128.0
" "	adult	♀	.....	Mollison, 1911	242	110.0	87.0	122.0
" "	adult	♂	Nat. M. 154722	Schultz	236	111.4	86.8	131.0
" *agilis*	juv.	?	.....	Mollison, 1911	173	114.0	88.0	122.0
" "	adult	♀	.....	Mollison, 1911	237	116.0	90.0	131.0
" "	adult	♂	Zo. I. Z. 136	Schultz	200	113.0	87.0	129.5
" "	adult	♂	Nat. M. 49694	"	247	118.2	87.4	134.4
" *concolor*	adult	♀	Nat. M. 198840	"	205	107.8	89.0	131.0
" spec.?	juv.	?	.....	Mollison, 1911	169	104.0	89.0	129.0
" "	adult	♂	.....	Boltze, 1926	197	123.9	87.5	122.8
" "	adult	?	.....	Mollison, 1911	205	114.0	91.0	127.0
" "	adult	♂	.....	Boltze, 1926	228	115.4	89.1	126.3
" "	adult	♂	.....	Boltze, 1926	240	113.3	87.4	125.9
Symphalangus klossi	adult	♀	Nat. M. 49657	Schultz	207	111.0	88.3	124.1
" "	adult	♂	Nat. M. 49656	"	196	116.3	88.7	127.6
Symphalangus syndact.	juv.	?	.....	Mollison, 1911	169	109.0	89.0	144.0
" "	juv.	?	.....	Mollison, 1911	179	109.0	86.0	142.0
" "	adult	?	.....	Mollison, 1911	258	116.0	90.0	145.0
" "	adult	?	.....	Mollison, 1911	259	112.0	84.0	146.0
" "	adult	?	Sch. 808	Schultz	261	111.5	86.3	145.3
" "	adult	♀	.....	Mollison, 1911	256	109.0	84.0	147.0
" "	adult	♀	.....	Mollison, 1911	261	114.0	86.0	146.0
" "	adult	♀	.....	Mollison, 1911	275	110.0	84.0	155.0
" "	adult	♀	.....	Mollison, 1911	275	113.0	85.0	150.0
" "	adult	♂	Sch. 130	Schultz	259	110.0	88.5	150.3
" "	adult	♂	.....	Mollison, 1911	261	114.0	88.0	148.0
" "	adult	♂	.....	Mollison, 1911	278	110.0	85.0	148.0
" "	adult	♂	.....	Mollison, 1911	279	108.0	88.0	146.0
" "	adult	♂	.....	Mollison, 1911	289	106.0	84.0	151.0
" "	adult	♂	Sch. 809	Schultz	289	113.4	88.6	149.3

TABLE XVII

The Limb Proportions of the ORANG-UTAN (Pongo Pygmaeus)

AGE	SEX	COLLECTION	MEASURED BY	HUMERUS LENGTH	BRACHIAL INDEX	CRURAL INDEX	INTERMEMBR. INDEX
infant	?	.....	Mollison, 1911	108	98.0	89.0	140.0
"	♂	.....	Mollison, 1911	134	97.0	89.0	146.0
"	♂	.....	Mollison, 1911	166	98.0	92.0	142.0
"	?	.....	Mollison, 1911	168	95.0	96.0	144.0
juven.	♀	.....	Mollison, 1911	180	102.0	100.0	150.0
"	♀	Nat. M. 49435	Schultz	206	97.1	95.9	142.8
"	?	.....	Mollison, 1911	232	98.0	88.0	139.0
"	♂	Nat. M. 49849	Schultz	236	97.5	90.4	146.5
"	♂	Nat. M. 49878	"	237	95.8	85.1	149.1
"	♂	.....	Mollison, 1911	248	98.0	95.0	145.0
"	♂	Nat. M. 49856	Schultz	283	100.7	89.8	145.1
"	?	Nat. M. 145303	"	286	104.5	94.3	141.8
"	♀	Wist. I. 2171	"	296	99.0	93.3	137.2
"	♂	.....	Mollison, 1911	297	96.0	90.0	141.0
adult	?	.....	Mollison, 1911	305	97.0	93.0	144.0
"	?	.....	Mollison, 1911	315	98.0	90.0	143.0
"	?	.....	Mollison, 1911	316	97.0	91.0	143.0
"	?	.....	Mollison, 1911	344	100.0	90.0	146.0
adult	♀	Nat. M. 153821	Schultz	305	100.8	97.8	139.0
"	♀	Wist. I. 7122	"	306	103.2	91.7	149.5
"	♀	Nat. M. 22937	"	307	102.5	88.0	147.6
"	♀	Ph. Acad. 12597	"	307	104.8	97.0	139.4
"	♀	Nat. M. 153822	"	309	94.8	93.6	143.9
"	♀	Wist. I. 2170	"	312	101.2	89.4	147.3
"	♀	Nat. M. 49862	"	313	102.2	91.6	139.2
"	♀	Nat. M. 145300	"	314	101.8	92.5	144.3
"	♀	Wist. I. 2222	"	315	100.8	90.5	150.9
"	♀	.....	Mollison, 1911	315	94.0	87.0	142.0
"	♀	Nat. M. 145302	Schultz	319	101.5	92.6	138.5
"	♀	Nat. M. 49769	"	320	101.8	91.6	142.2
"	♀	Nat. M. 49857	"	322	97.5	89.9	147.5
"	♀	Nat. M. 145309	"	322	104.9	93.8	141.2
"	♀	Nat. M. 49851	"	326	101.2	94.5	143.5
"	♀	Nat. M. 145308	"	326	104.8	97.0	145.4
"	♀	.....	Mollison, 1911	328	96.0	92.0	149.0
"	♀	Nat. M. 49853	Schultz	329	100.5	85.9	143.1
"	♀	Wist. I. 2173	"	330	100.5	91.7	143.2
"	♀	Nat. M. 49863	"	331	99.1	90.5	149.6
"	♀	.....	Mollison, 1911	331	101.0	91.0	143.0
"	♀	.....	Mollison, 1911	332	99.0	91.0	145.0
"	♀	Nat. M. 145306	Schultz	334	104.7	94.6	147.0
"	♀	.....	Mollison, 1911	335	103.0	94.0	149.0
"	♀	Nat. M. 49768	Schultz	336	99.7	98.4	142.7
"	♀	Wist. I. 2172	"	339	98.2	91.2	141.6
"	♀	.....	Mollison, 1911	339	98.0	87.0	145.0

TABLE XVII (continued)

AGE	SEX	COLLECTION	MEASURED BY	HUMERUS LENGTH	BRACHIAL INDEX	CRURAL INDEX	INTERMEMBR. INDEX
adult	♀	Nat. M. 49848	Schultz	340	98.5	93.8	145.0
"	♀	Wist. I. 319	"	344	100.5	91.1	147.3
"	♀	Nat. M. 145304	"	355	107.5	93.5	145.8
adult	♂	Wist. L. 1559	Schultz	320	103.7	93.9	146.8
"	♂	.....	Mollison, 1911	329	101.0	93.0	144.0
"	♂	Wist. I. 5646	Schultz	332	99.1	92.8	145.8
"	♂	Nat. M. 145310	"	341	107.3	94.3	139.1
"	♂	Wist. I. 7120	"	342	104.3	94.7	148.3
"	♂	.....	Mollison, 1911	342	104.0	96.0	136.0
"	♂	Wist. I. 2213	Schultz	346	102.8	95.7	142.3
"	♂	Wist. I. 2223	"	358	97.5	92.0	146.6
"	♂	Nat. M. 49864	"	359	95.3	89.4	146.2
"	♂	Wist. I. 5645	"	360	101.6	87.6	149.9
"	♂	.....	Fick, 1895	360	104.1	87.3	142.6
"	♂	.....	Mollison, 1911	360	104.0	93.0	141.0
"	♂	.....	Duvernoy, 1856	362	101.8	90.8	141.8
"	♂	Nat. M. 145305	Schultz	362	108.5	96.0	142.0
"	♂	Wist. I. 5644	"	363	101.3	92.7	146.4
"	♂	.....	Mollison, 1911	364	100.0	90.0	148.0
"	♂	.....	Mollison, 1911	365	100.0	89.0	136.0
"	♂	Nat. M. 49860	Schultz	365	101.8	86.5	136.7
"	♂	.....	Delisle, 1895	366	100.0	88.8	140.4
"	♂	Wist. I. 2168	Schultz	366	103.7	94.6	137.8
"	♂	Nat. M. 49858	"	371	96.2	84.9	138.0
"	♂	Nat. M. 49855	"	373	98.4	88.2	145.0
"	♂	.....	Mollison, 1911	374	101.0	94.0	148.0
"	♂	.....	Mollison, 1911	380	97.0	94.0	144.0
"	♂	.....	Fick, 1895	380	107.8	88.2	142.2
"	♂	.....	Delisle, 1895	382	100.6	91.6	140.5
"	♂	A. Jeff.	Schultz	384	99.0	90.0	144.0
"	♂	Nat. M. 145301	"	384	103.4	95.6	145.2
"	♂	Nat. M. 153823	"	385	98.7	91.8	141.8
"	♂	.....	Mollison, 1911	386	94.0	89.0	148.0
"	♂	.....	Delisle, 1895	393	100.4	102.9	143.7
"	♂	Nat. M. 49859	Schultz	409	91.7	90.7	142.2

TABLE XVIII

The Limb Proportions of the CHIMPANZEE (Pan Spec. ?)

AGE	SEX	COLLECTION	MEASURED BY	HUMERUS LENGTH	BRACHIAL INDEX	CRURAL INDEX	INTERMEMBR. INDEX
juven.	?	.....	Mollison, 1911	139	94.0	82.0	112.0
"	♀	.....	Mollison, 1911	145	88.0	80.0	104.0
"	?	.....	Mollison, 1911	157	90.0	87.0	111.0
"	♀	.....	Mollison, 1911	174	92.0	86.0	105.0
"	♂	Sch. 310	Schlultz	179	91.1	84.1	109.9
"	?	.....	Mollison, 1911	181	91.0	78.0	113.0
"	?	.....	Mollison, 1911	191	92.0	81.0	110.0
adult	?	.....	Bolk, 1926	280	94.6	81.9	108.6
"	?	.....	Mollison, 1911	291	91.0	80.0	106.0
"	?	.....	Mollison, 1911	308	95.0	86.0	110.0
"	?	.....	Duvernoy, 1856	325	92.3	80.3	110.0
adult	♀	Nat. M. 236971	Schultz	251	92.9	82.2	105.3
"	♀	P. A. L. 9	"	262	92.0	78.4	108.9
"	♀	Ph. Acad. 13104	"	265	96.2	85.3	100.6
"	♀	.....	Mollison, 1911	266	94.0	86.0	105.0
"	♀	.....	Mollison, 1911	279	96.0	85.0	104.0
"	♀	Nat. M. 176226	Schultz	284	85.6	83.0	106.1
"	♀	Nat. M. 176227	"	286	90.9	85.8	107.1
"	♀	Nat. M. 220063	"	292	94.5	84.4	111.5
"	♀	Nat. M. 220062	"	293	90.5	86.9	108.5
"	♀	.....	Mollison, 1911	302	88.0	86.0	111.0
"	♀	Nat. M. 176229	Schultz	318	94.7	86.1	110.4
"	♀	Nat. M. 220064	"	327	92.7	86.1	112.0
adult	♂	Nat. M. 220065	Schultz	292	92.1	81.5	107.6
"	♂	Nat. M. 220327	"	295	98.0	88.8	108.0
"	♂	.....	Mollison, 1911	296	94.0	82.0	104.0
"	♂	.....	Lorenz, 1917	297	93.6	83.3	100.5
"	♂	.....	Mollison, 1911	301	95.0	84.0	110.0
"	♂	.....	Mollison, 1911	309	93.0	84.0	108.0
"	♂	.....	Mollison, 1911	310	91.0	83.0	107.0
"	♂	.....	Mollison, 1911	312	96.0	85.0	105.0
"	♂	Nat. M. 220326	Schultz	322	89.4	81.2	110.7
"	♂	Nat. M. 176228	"	323	90.1	84.2	105.4
"	♂	Nat. M. 176230	"	323	94.2	85.5	106.2
"	♂	W. R. U. B 239	Straus	339	93.2	83.4	111.5
"	♂	Nat. M.174698	Schultz	345	85.1	79.2	113.7

TABLE XIX

The Limb Proportions of the GORILLA (Gorilla Gorilla, G. Graueri or G. Gorilla Graueri, and G. Beringei)

SPECIES	AGE	SEX	COLLECTION	MEASURED BY	HUMERUS LENGTH	BRACHIAL INDEX	CRURAL INDEX	INTERMEMBRAL INDEX
Gorilla gorilla	infant	?	.....	Bolk, 1926	152	86.2	81.6	124.7
" "	infant	?	.....	Deniker, 1885	170	81.8	85.2	123.5
" "	infant	♂	W. R. U. B 169	Straus	181	83.5	82.5	122.9
" "	infant	♀	P. A. L. 5	Schultz	207	80.2	83.7	114.1
Gorilla gorilla	juv.	?	.....	Bolk, 1926	240	86.7	77.7	117.3
" "	juv.	♂	.....	Mollison, 1911	266	79.0	82.0	120.0
" "	juv.	♂	P. A. L. 3	Schultz	276	77.9	84.8	118.5
" "	juv.	♂	P. A. L. 10	"	364	81.1	81.3	119.2
Gorilla gorilla	adult	♀	W. R. U. B 626	Straus	344	84.7	78.7	120.0
" "	adult	♀	.....	Mollison, 1911	353	81.0	84.0	116.0
" "	adult	♀	.....	Lorenz, 1917	354	79.4	80.5	118.0
" "	adult	♀	.....	Mollison, 1911	356	80.0	80.0	121.0
" "	adult	♀	W. R. U. B 824	Straus	357	82.4	81.1	119.3
" "	adult	♀	P. A. L. 2	Schultz	357	78.2	82.3	116.3
" "	adult	♀	Nat. M. 220060	"	357	79.3	78.7	118.3
" "	adult	♀	Ph. Acad. 3319	"	358	82.4	84.0	113.3
" "	adult	♀	.....	Mollison, 1911	359	83.0	80.0	121.0
" "	adult	♀	W. R. U. B 627	Straus	360	84.2	83.3	121.3
" "	adult	♀	Dealer, Berlin	Schultz	362	80.1	78.7	121.6
" "	adult	♀	.....	Mollison, 1911	365	82.0	85.0	113.0
" "	adult	♀	P. A. L. 6	Schultz	365	79.7	82.8	116.1
" "	adult	♀	.....	Deniker, 1885	370	81.5	78.0	110.8
" "	adult	♀	P. A. L. 14	Schultz	375	77.3	82.7	120.9
" "	adult	♀	.....	Mollison, 1911	378	81.0	83.0	113.0
" "	adult	♀	.....	Bolk, 1926	380	80.3	78.6	118.7
" "	adult	♀	.....	Mollison, 1911	382	79.0	81.0	117.0
" "	adult	♀	.....	Duvernoy, 1856	390	80.0	80.3	112.8
" "	adult	♀	Nat. M. 154553	Schultz	398	81.7	78.0	117.8
" "	adult	♀	Amer. M. 54355	"	403	77.4	78.1	114.0
Gorilla gorilla	adult	♂	Nat. M. 174723	Schultz	402	83.6	80.2	114.3
" "	adult	♂	Nat. M. 174722	"	403	77.9	78.3	114.4
" "	adult	♂	.....	Mollison, 1911	403	79.0	78.0	119.0
" "	adult	♂	Ph. Acad. 5530	Schultz	406	84.7	81.5	121.1
" "	adult	♂	Amer. M. 69398	"	407	81.6	80.6	118.6
" "	adult	♂	P. A. L. 11	"	411	82.0	80.9	116.2
" "	adult	♂	.....	Mollison, 1911	412	78.0	79.0	116.0
" "	adult	♂	Wist. I. 4491	Schultz	412	82.8	77.1	119.1
" "	adult	♂	Amer. M. 54356	"	421	80.3	79.7	117.7
" "	adult	♂	P. A. L. 1	"	424	78.9	79.5	115.4
" "	adult	♂	W. R. U. B 624	Straus	425	85.2	77.3	117.3
" "	adult	♂	.....	Lorenz, 1917	427	83.4	82.3	113.3
" "	adult	♂	.....	Mollison, 1911	427	83.0	77.0	112.0
" "	adult	♂	.....	Mollison, 1911	428	80.0	79.0	118.0
" "	adult	♂	.....	Mollison, 1911	428	83.0	78.0	121.0
" "	adult	♂	Ph. Acad. 11805	Schultz	431	80.3	79.0	120.2
" "	adult	♂	Zo. Col.	"	432	80.5	80.5	115.2
" "	adult	♂	Nat. M. 220325	"	433	81.3	78.3	117.9
" "	adult	♂	.....	Mollison, 1911	434	83.0	84.0	114.0
" "	adult	♂	.....	Mollison, 1911	435	85.0	77.0	119.0

TABLE XIX (continued)

SPECIES	AGE	SEX	COLLECTION	MEASURED BY	HUMERUS LENGTH	BRACHIAL INDEX	CRURAL INDEX	INTERMEMBRAL INDEX
Gorilla gorilla	adult	♂	.....	Mollison, 1911	437	82.0	81.0	115.0
" "	adult	♂	.....	Lorenz, 1917	440	80.0	85.8	116.1
" "	adult	♂	.....	Duvernoy, 1856	440	75.4	81.4	114.6
" "	adult	♂	.....	Mollison, 1911	441	81.0	79.0	116.0
" "	adult	♂	P. A. L. 12	Schultz	442	80.1	81.7	114.4
" "	adult	♂	P. A. L. 13	"	447	78.1	79.2	117.2
" "	adult	♂	.....	Bolk, 1926	452	83.6	80.1	113.2
" "	adult	♂	.....	Du Chaillu, 1861	457	75.7	80.0	123.4
" "	adult	♂	W. R. U. B 1020	Straus	460	75.7	83.1	116.3
" "	adult	♂	P. A. L. 8	Schultz	480	76.5	79.8	119.0
Gorilla graueri	adult	♀	.....	Lorenz, 1917	372	75.5	77.8	116.0
" "	adult	♀	.....	Lorenz, 1917	385	74.5	76.0	115.6
" "	adult	♂	.....	Lorenz, 1917	428	79.2	77.0	118.5
" "	adult	♂	.....	Lorenz, 1917	447	76.3	78.5	115.4
" "	adult	♂	.....	Lorenz, 1917	465	75.5	80.7	115.7
Gorilla beringei	infant	♂	Nat. M. 239884	Schultz	188	79.8	75.5	121.1
" "	juv.	♂	Amer. M.	"	250	76.0	75.6	115.5
" "	juv.	♀	P. A. L. 7	"	326	84.0	81.8	111.5
Gorilla beringei	adult	♀	Amer. M. 54091	Schultz	344	85.0	79.8	113.8
" "	adult	♀	Amer. M. 54092	"	362	83.5	85.9	109.6
" "	adult	♂	Amer. M. 54090	"	390	88.5	79.3	110.2
" "	adult	♂	Amer. M. 54089	"	412	87.4	83.1	111.6
" "	adult	♂	Nat. M. 239883	"	435	83.2	79.5	116.8

TABLE XX

Some Proportions in the Skeleton of the HAND of Primates. The Specimens Are Listed According to Increasing Length of Ray III (Metacarpus + Phalanges of Middle Finger) in the Same Species and Sex. The 11 *Hand Skeletons of Negroes and Whites from the Anatomy Department of the University of Maryland Were Kindly Measured for the Writer by Dr. W. L. Straus, Jr.*

PRIMATE	AGE	SEX	COLLECTION	RAY III LENGTH (MM.)	RAY I LENGTH / RAY III LENGTH	PHALANGES III LENGTH / RAY III LENGTH	PHALANGES I LENGTH / RAY I LENGTH
Cebus capucinus	adult	♂	A. Hopk. 249 a	67	58.2	64.2	56.4
Alouatta seniculus	adult	♂	Sch. 763	112	52.7	67.8	61.0
Pithecus rhesus	adult	♂	Sch. 333	87	46.0	57.8	47.5
Papio hamadryas	juv.	♂	A. Hopk. 15	58	53.4	51.7	45.2
Pygathrix germaini	adult	♂	A. Hopk. 139	96	39.6	59.4	50.0
Hylobates leuciscus	juv.	♂	Nat. M. 156296	109	41.3	61.5	48.8
Hylobates leuciscus	adult	♂	Nat. M. 154722	132	42.4	59.1	46.4
Hylobates agilis	adult	♂	Nat. M. 49694	157	44.5	61.7	50.0
Hylobates lar	adult	♂	Sch. 907	149	44.9	59.0	47.7
Symphalangus klossi	adult	♀	Nat. M. 49657	119	47.0	60.5	50.0
Symphalangus klossi	adult	♂	Nat. M. 49656	121	47.1	61.1	49.1
Symphalangus syndact.	adult	♂	Sch. 130	153	44.4	60.1	48.5
Pongo pygmaeus	juv.	♂	Nat. M. 49849	175	30.3	59.5	49.0
Pongo pygmaeus	juv.	♂	Nat. M. 49960	197	35.0	56.9	49.3
Pongo pygmaeus	adult	♀	Nat. M. 153805	207	35.7	57.0	47.3
Pongo pygmaeus	adult	♂	Nat. M. 145301	279	37.3	57.4	46.2
Pan spec.?	adult	♀	P. A. L. 9	175	39.4	57.2	50.7
Pan spec.?	adult	♂	Nat. M. 220326	199	39.7	60.4	50.6
Gorilla gorilla	adult	♀	P. A. L. 14	184	45.6	57.6	50.0
Gorilla gorilla	adult	♀	P. A. L. 6	188	44.6	58.0	50.0
Gorilla gorilla	adult	♀	P. A. L. 2	191	42.3	57.1	44.4
Gorilla gorilla	juv.	♂	P. A. L. 10	192	44.7	57.3	50.0
Gorilla gorilla	adult	♂	P. A. L. 13	211	42.1	55.9	43.8
Gorilla gorilla	adult	♂	P. A. L. 1	214	44.3	57.0	48.4
Gorilla gorilla	adult	♂	P. A. L. 11	224	46.4	58.0	48.1
Gorilla gorilla	adult	♂	P. A. L. 12	226	45.1	56.6	49.0
Gorilla gorilla	adult	♂	P. A. L. 8	231	45.9	56.3	47.2
Gorilla beringei	juv.	♀	P. A. L. 7	173	49.7	59.0	50.0
Gorilla beringei	adult	♀	Amer. M. 54091	173	48.0	60.7	50.6
Gorilla beringei	adult	♂	Amer. M. 54089	198	51.5	59.1	52.0
Gorilla beringei	adult	♂	Nat. M. 239883	208	52.0	57.3	50.0
Gorilla beringei	adult	♂	Amer. M. 54090	217	48.0	59.5	50.9

TABLE XX (continued)

PRIMATE	AGE	SEX	COLLECTION	RAY III LENGTH (MM.)	RAY I LENGTH / RAY III LENGTH	PHALANGES III LENGTH / RAY III LENGTH	PHALANGES I LENGHT / RAY I LENGTH
Homo (Negro)	adult	♀	A. Hopk.	149	63.7	59.7	52.6
Homo (Negro)	adult	♀	A. Hopk.	149	63.7	57.7	51.6
Homo (Negro)	adult	♀	P. A. L.	162	60.4	59.2	53.1
Homo (Negro)	adult	♀	Univ. of Md. 113	169	64.5	59.2	53.2
Homo (Negro)	adult	♂	A. Hopk.	159	61.0	57.8	53.6
Homo (Negro)	adult	♂	Univ. of Md. 120	160	61.8	58.7	52.5
Homo (Negro)	adult	♂	P. A. L.	162	61.6	58.6	53.0
Homo (Negro)	adult	♂	A. Hopk. 356	165	61.8	58.1	52.9
Homo (Negro)	adult	♂	P. A. L.	166	63.9	59.6	53.8
Homo (Negro)	adult	♂	A. Hopk. 353 E	169	65.1	59.8	52.7
Homo (Negro)	adult	♂	A. Hopk. 403 E	170	63.5	60.0	56.5
Homo (Negro)	adult	♂	Univ. of Md. 106	175	62.3	58.3	51.4
Homo (Negro)	adult	♂	A. Hopk. 380	176	61.9	58.5	54.1
Homo (Negro)	adult	♂	P. A. L.	176	63.6	60.2	54.4
Homo (Negro)	adult	♂	A. Hopk. 406 E	177	60.5	60.5	55.1
Homo (Negro)	adult	♂	P. A. L.	177	62.7	60.5	53.1
Homo (Negro)	adult	♂	A. Hopk. 408 E	179	61.5	57.0	54.5
Homo (Negro)	adult	♂	Univ. of Md. 130	185	63.8	57.3	53.4
Homo (White)	adult	♀	Univ. of Md. 121	137	59.8	56.9	51.2
Homo (White)	adult	♀	Univ. of Md. 98	147	63.9	57.1	52.1
Homo (White)	adult	♀	P. A. L.	147	65.9	59.1	52.5
Homo (White)	adult	♂	P. A. L.....	153	63.4	59.4	52.6
Homo (White)	adult	♂	Univ. of Md. 104	154	61.0	57.1	53.2
Homo (White)	adult	♂	A. Hopk. 411 F	158	64.6	58.8	52.9
Homo (White)	adult	♂	Univ. of Md. 100	158	65.9	57.6	51.9
Homo (White)	adult	♂	A. Hopk. 405 E	160	66.3	59.3	53.7
Homo (White)	adult	♂	Univ. of Md. 111	162	64.9	61.0	54.3
Homo (White)	adult	♂	A. Hopk. 418	163	65.1	59.5	53.7
Homo (White)	adult	♂	A. Hopk.	165	64.3	58.7	50.9
Homo (White)	adult	♂	Univ. of Md. 118	172	65.1	58.1	53.5
Homo (White)	adult	♂	Univ. of Md. 129	174	66.1	59.2	53.0
Homo (White)	adult	♂	P. A. L.	176	64.8	61.4	50.9

TABLE XXI

The Total Length (in Mm.) and Some Proportions of the Skeleton of the FOOT of Primates

PRIMATE	AGE	SEX	COLLECTION	TOTAL FOOT LENGTH	TARSUS LENGTH / TOTAL FOOT LENGTH	METATARSUS III L. / TOTAL FOOT LENGTH	PHALANGES III L. / TOTAL FOOT LENGTH	RAY I LENGTH / RAY III LENGTH	PHALANGES I L. / METATARSUS I L.
Cebus capucinus	adult	♂	A. Hopk. 249 b	127	32.3	30.7	37.0	66.2	90.0
Alouatta seniculus	adult	♂	Sch. 763	168	29.2	30.3	40.5	56.3	91.4
Pithecus rhesus	adult	♀	A. Hopk. 99	128	32.0	32.8	35.2	51.7	73.1
Pygathrix germaini	adult	♂	A. Hopk. 139	164	29.2	30.5	40.3	52.6	72.2
Lasiopyga pygerythra	adult	♂	A. Hopk. 148	147	32.6	32.6	34.8	53.5	76.7
Colobus abyssinicus	adult	♀	Amer. M. 52223	169	30.1	32.5	37.4	46.6	77.5
Hylobates pileatus	adult	♀	A. Hopk. 133	137.5	28.3	30.5	41.2	68.0	76.3
Hylobates pileatus	adult	♀	A. Hopk. 126	138.5	27.8	31.0	41.2	54.0	86.2
Hylobates agilis	adult	♂	Nat. M. 49694	148	27.0	29.7	43.3	70.3	90.0
Hylobates lar	adult	♂	Nat. M. 49463	139	28.0	30.2	41.8	71.0	73.2
Hylobates lar	adult	♂	Sch. 907	141	26.9	31.2	41.9	66.0	83.8
Hylobates leuciscus	juv.	♂	Nat. M. 156296	110	30.0	29.1	40.9	68.8	89.3
Hylobates leuciscus	adult	♂	Nat. M. 154722	132	29.5	31.8	38.7	67.8	80.0
Symphalangus klossi	adult	♀	Nat. M. 49657	122	28.7	30.3	41.0	69.0	81.8
Symphalangus klossi	adult	♂	Nat. M. 49656	122	29.5	30.3	40.2	70.9	79.4
Symphalangus synd.	adult	♂	Sch. 130	151	25.8	32.4	41.8	66.9	92.3
Pongo pygmaeus	juv.	?	Wist. I. 2174	126.5	25.3	30.1	44.6	28.0	82.8
Pongo pygmaeus	juv.	♂	Nat. M. 49849	209	25.4	30.1	44.5	34.6	86.2
Pongo pygmaeus	juv.	?	Nat. M. 49960	254	27.1	31.5	41.4	34.0	65.8
Pongo pygmaeus	adult	♂	Wist. I. 2173	293	26.3	31.3	42.4	40.7	72.5
Pongo pygmaeus	adult	♂	Wist. I. 2223	305	26.5	30.1	43.4	40.1	100.0
Pan. spec.?	adult	♀	P. A. L. 9	191	34.0	29.8	36.2	69.0	93.3
Pan. spec.?	adult	♂	Nat. M. 220326	234	36.7	28.2	35.1	64.1	93.9
Gorilla gorilla	adult	♀	R. A. L. 14	241	37.3	28.2	34.5	62.9	86.2
Gorilla gorilla	adult	♀	P. A. L. 6	251	37.5	27.9	34.6	64.4	87.1
Gorilla gorilla	adult	♀	P. A. L. 2	259	38.6	27.8	33.6	60.4	88.2
Gorilla gorilla	juv.	♂	P. A. L. 10	255	38.0	28.6	33.4	64.6	88.9
Gorilla gorilla	adult	♂	P. A. L. 13	278	42.4	27.0	30.6	68.2	81.7
Gorilla gorilla	adult	♂	P. A. L. 12	292	40.8	27.4	31.8	68.8	105.0
Gorilla gorilla	adult	♂	P. A. L. 1	294	40.5	27.5	32.0	60.0	78.0
Gorilla gorilla	adult	♂	P. A. L. 11	303	39.6	27.4	33.0	66.1	92.1
Gorilla gorilla	adult	♂	P. A. L. 8	318	40.9	26.4	32.7	68.1	91.0
Gorilla beringei	juv.	♀	P. A. L. 7	230	38.7	27.8	33.5	68.8	90.2
Gorilla beringei	adult	♀	Amer. M. 54091	223	40.8	26.0	33.2	74.2	96.0
Gorilla beringei	adult	♀	Amer. M. C. A. 47	241	37.7	27.8	34.5	72.7	84.7
Gorilla beringei	adult	♂	Amer. M. 54090	259	41.4	25.9	32.7	73.7	96.5
Gorilla beringei	adult	♂	Nat. M. 239883	273	43.3	26.0	30.7	77.8	93.5
Gorilla beringei	adult	♂	Amer. M. 54089	283	42.1	25.1	32.8	70.5	97.4
Homo (Negro)	adult	♀	A. Hopk. . .	201	50.7	32.3	17.0	108.1	91.1
Homo (Negro)	adult	♂	P. A. L. . .	215	49.8	29.8	20.4	99.1	94.5
Homo (Negro)	adult	♂	A. Hopk. . .	234	49.2	30.3	20.5	100.0	86.0
Homo (Negro)	adult	♂	P. A. L. . .	248	47.2	31.0	21.8	91.7	90.5
Homo (Negro)	adult	♂	P. A. L. . .	252	48.8	28.9	22.3	92.3	98.3
Homo (Negro)	adult	♂	P. A. L. . .	264	48.8	29.1	22.1	94.9	100.5
Homo (White)	adult	♂	P. A. L. . .	226	50.0	28.7	21.3	94.8	87.8
Homo (White)	adult	♂	P. A. L. . .	237	50.1	29.5	20.4	99.2	91.8
Homo (White)	adult	♂	P. A. L. . .	242	48.0	28.5	23.5	94.5	95.1
Homo (White)	adult	♂	A. Hopk. . .	253	49.0	28.1	22.9	97.0	95.3

NOTES

INTERIM REPORT ON THE SKULL OF SINANTHROPUS MARCH 29, 1930*

Since my last report before the Society, work has progressed on the *Sinanthropus* skull specimen till now its whole external surface has been freed from travertine, with which however its interior is still filled. Various phases of the work of preparation are illustrated by the lantern slides. The whole of the frontal bone and the major parts of both parietals, which during their preparation were separated from the stone filling the interior, have now temporarily been replaced so that the specimen as a whole could be photographed with its parts in approximately correct relation. The cracks which are now so evident between various parts of the skull vault can be eliminated only after the interior of the specimen has been completely cleared of travertine. These natural size photographs were taken with a short focus lens and so do not represent geometrically correct projections.

The preliminary photographs show in unmistakable fashion certain of the major characters which serve sharply to distinguish *Sinanthropus* from other hominid types ancient or modern. In *Sinanthropus* the maximum skull breadth falls between the supramastoid elements of the temporal bones, the narrower maximum, interparietal breadth lying between points close to the postero-lateral angles of the parietals. Thus, though the parietal eminences are quite well developed, the sides of the cranial vault below them are markedly inclined toward one another.

The bones of the cranial vault show considerable variation in their thickness, being much thicker in certain regions (e.g. below the lambda) than was at first supposed. They are on the whole thicker than in the average modern skull but, at least in the fronto-parietal region, they fall far short of being of the excessive thickness so characteristic of this region in *Eoanthropus*.

Certain unique morphological features which were obscure in the earlier stages of preparation are now to be seen in the lateral and basal views of the specimen. In my preliminary note reference was made

*Read at the Annual Meeting of the Geological Society of China, and published in the *Bulletin of the Geological Society of China*, Vol. IX, No. 1, 1930.

to what appeared to be a markedly developed post-glenoid process. The hard calcareous deposit in the mandibular fossae and about the external auditory passages has now been removed and it becomes clearly evident that the structure previously considered as part of a post-glenoid process is in reality a very peculiarly developed tympanic portion of the temporal bone. The mid-part of the floor of the external auditory meatus is deficient for some distance inwards, leaving a deep and narrow fissure between massive anterior and posterior parts of the tympanic element. In the latter the posterior moiety is developed to form a prominent crest which extends inwards to the base of the minute styloid process, the anterior portion forming a massive rounded wall limiting the mandibular fossa behind the petro-tympanic fissure. The relations obtaining in these parts are of extraordinary interest since here for the first time among hominids a stage of development is manifest which is much more archaic than that obtaining in Neanderthal man while at the same time it presents features recalling the relations characterizing this region in anthropoids (e.g.Chimpanzee).

Boule pointed out long ago that the morphology of the tympanic element in the La Chapelle skull recalls in certain respects the conditions obtaining in that region in the chimpanzee, presenting characters somewhat intermediate in type between the latter form and *Homo*. The relations of these parts in the *Sinanthropus* specimen may thus with propriety be termed pre-Neanderthaloid, representing an evolutionary stage preceding the Neanderthal-like types. The morphological evidence so far available with respect to the position of *Sinanthropus* in the hominid scale would thus place the latter form not far removed from the type from which evolved both the extinct Neanderthaler and the modern *Homo sapiens*.

Davidson Black.
Honorary Director.

Cenozoic Research Laboratory.
Geological Survey of China.

ERRATUM

The following sentence in my article "A Critique of Professor Frederic Wood-Jones's Paper . . . " (Human Biology, Vol. II, No. 1, p. 105) is erroneous and should be deleted:

" . . . In the existing African lemuroids the tympanic bone is no longer enclosed within the bulla, but few would argue that in general the auditory regions of *Galago* and *Nycticebus* are more primitive than those of *Notharctus* and *Adapis*." William K. Gregory

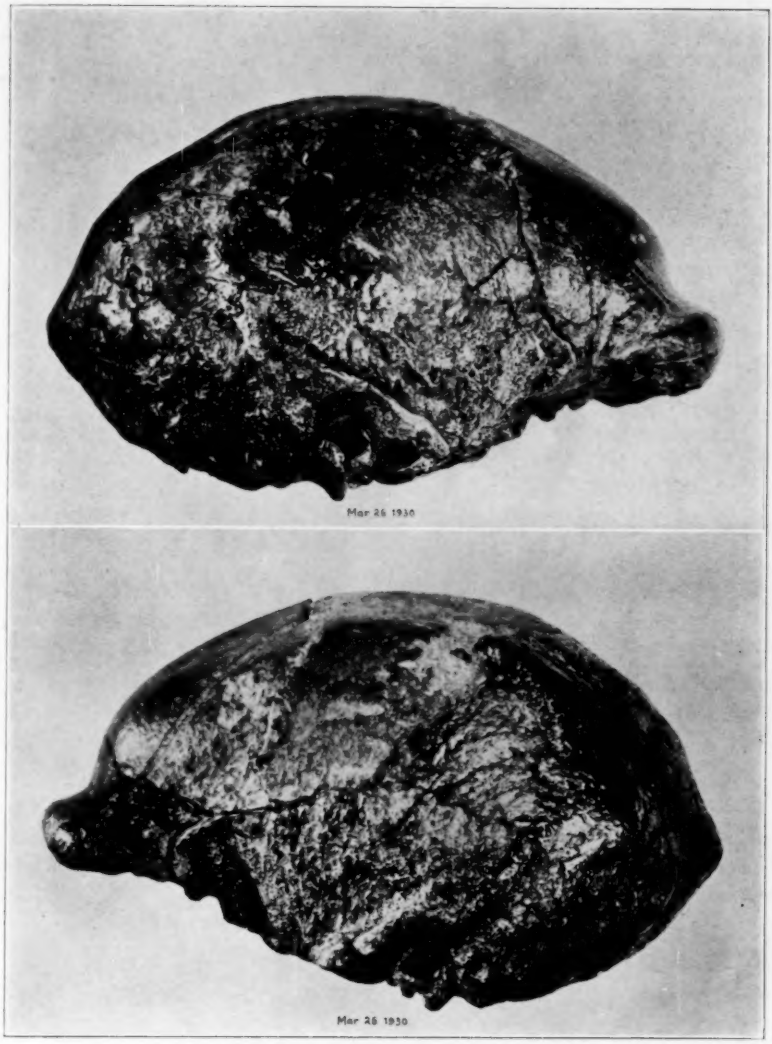

FIG. 1. Right and left lateral views of the skull of Sinanthropus.

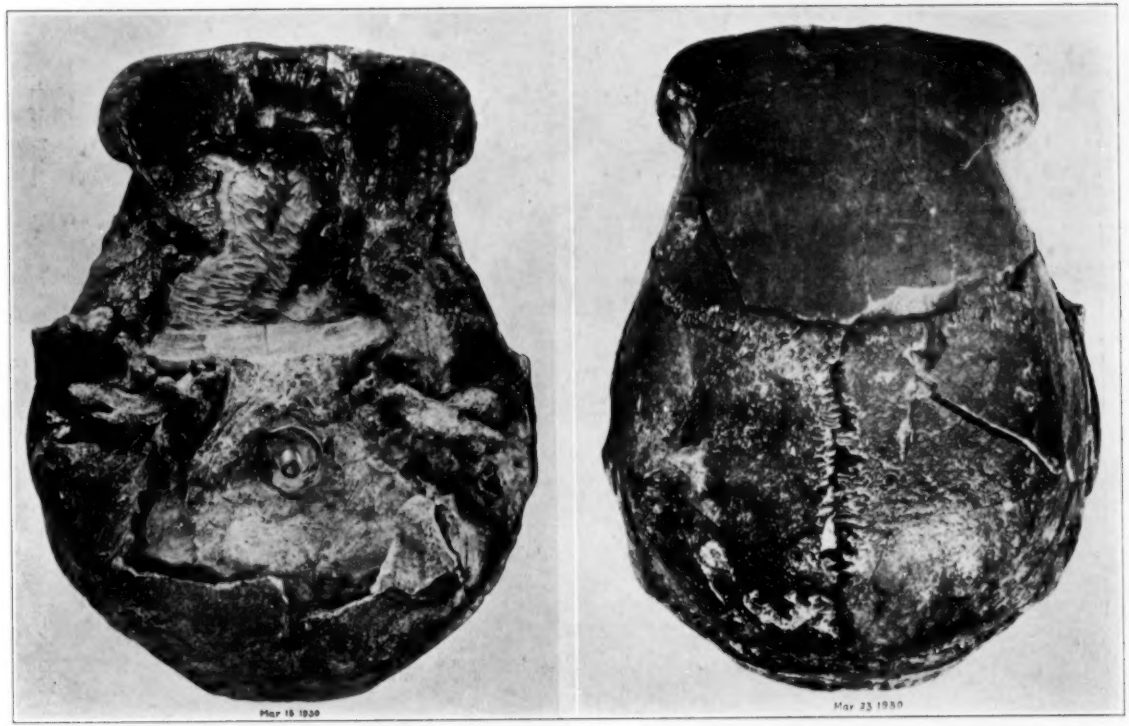

FIG. 2. Basal and vertical views of the skull of Sinanthropus.

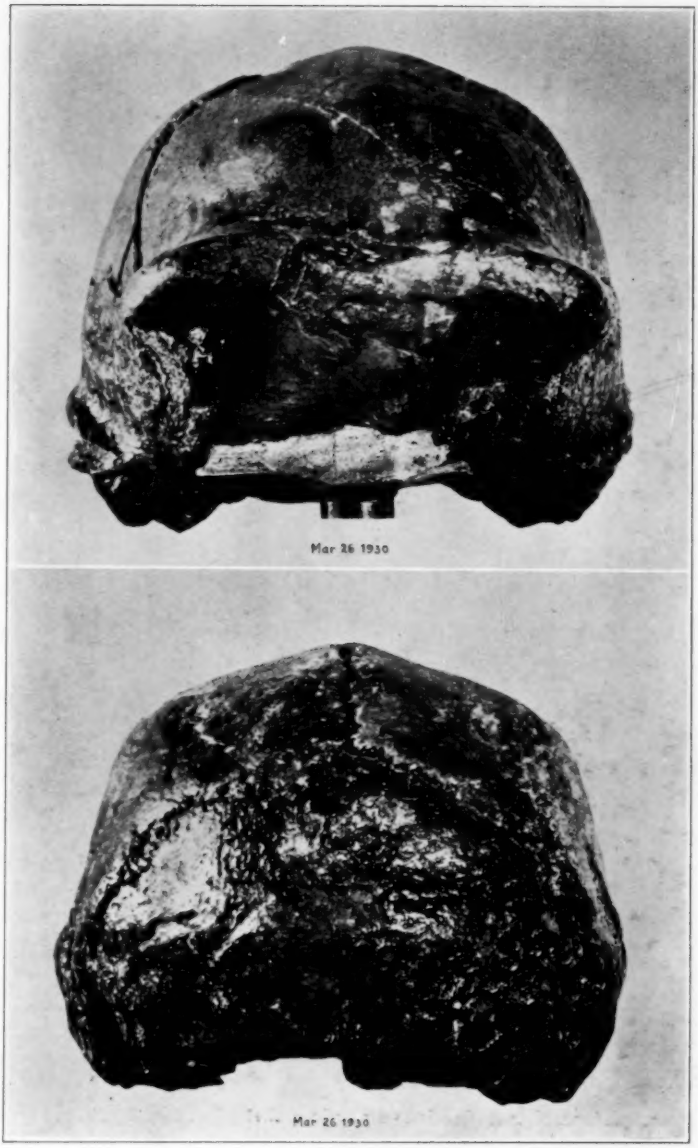

FIG. 3. Anterior and posterior views of the skull of Sinanthropus.

RECENT LITERATURE

USEFUL IN THE STUDY OF HUMAN BIOLOGY

In this department will be noticed the books and reprints which are currently received at the Editorial Office. Publications intended for notice here should be addressed to Dr. Raymond Pearl, Department of Biology, School of Hygiene and Public Health, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

I. EVOLUTION AND GENETICS

ANDERSON, SAMUEL E. The law of continuity. A study in heredity disguised as a short story. 14 pp. (No place of publication given.)

BLACK, DAVIDSON. Preliminary notice of the discovery of an adult *Sinanthropus* skull at Chou Kou Tien. *Bulletin of the Geological Society of China*, Vol. VIII, pp. 207–231, 1929.

BLUHM, AGNES. Über eine entgegengesetzt gerichtete Mutation und Modifikation, bewirkt durch einunddasselbe Agens (Alkohol). *Biologischen Zentralblatt*, Bd. 50, Heft 2, pp. 102–113, 1930.

BREUIL, ABBÉ HENRI, and M. C. BURKITT, with the collaboration of Sir Montagu Pollock. Rock Paintings of Southern Andalusia. A Description of a Neolithic and Copper Age Art Group. *New York* (Oxford University Press), 1929. Pp. xii + 88 + 33 plates and 7 maps. 10 × 12½ inches. $25.

DE CHARDIN, P. TEILHARD, and C. C. YOUNG. Preliminary report on the Chou Kou Tien fossiliferous deposit. *Bulletin of the Geological Society of China*, Vol. VIII, pp. 173–202, 1929.

CLARK, AUSTIN H. The New Evolution. Zoögenesis. *Baltimore* (The Williams and Wilkins Co.), 1930. Pp. xiv + 297. 5⅝ × 8½ inches. $3.00.

CONKLIN, EDWIN G. Principles and possibilities of human evolution. *International Clinics*, Vol. I, Series 40, 20 pp. 1930.

CROUZON, O. Études sur les Maladies Familiales Nerveuses et Dystrophiques. *Paris* (Masson et Cie), 1929. Pp. viii + 385. 6¼ × 9⅛ inches. 55 francs (paper).

CURTIUS, FRIEDRICH. Nachgeburtsbefunde bei Zwillingen und Ähnlichkeitsdiagnose. *Zeitschrift für induktive Abstammungs- und Vererbungslehre*, Band LIV, pp. 278–279, 1930.

DAVENPORT, CHARLES B. Annual Report of the Director of the Department of Genetics, Carnegie Institution of Washington. *Year Book* No. 28, 1928–1929, pp. 33–66, December 12, 1929.

DAVENPORT, CHARLES B., HARRISON R. HUNT, and GEORGE H. SHULL. Laws against cousin marriages: would eugenicists alter them? *Eugenics*, Vol. II, pp. 2–3, 1929.

EKMAN, GUNNAR. Über Entwicklung und Vererbung. *Suomalaisen Eläin- ja Kasvitieteellisen Seuran Vanamon Julkaisuja.* Osa 10. No. 1. *Annales Societatis Zoolog.-Botanicæ Fennicæ Vanamo.* Tom. 10. No. 1. Pp. 1–141, with 29 text figures. 1930.

FISCHER, E. Versuch einer Genanalyse des Menschen. *Zeitschrift für induktive Abstammungs- und Vererbungslehre*, Band LIV, Heft 1/2, pp. 127–234, 1930.

FISHER, R. A. The Genetical Theory of Natural Selection. *New York* (Oxford University Press), 1930. Pp. xiv + 272. 6¼ × 9¼ inches. $6.00.

LOEB, LEO. Heredity and internal secretion in the etiology of cancer. Communicated to the *International Cancer Conference in London*, July, 1928. 15 pp.

LOEFFLER, LOTHAR. Röntgenschädigungen der männlichen Keimzelle und Nachkommenschaft. Ergebnisse einer Umfrage bei Röntgenärzten und -technikern. *Strahlen-therapie*, Band 34, pp. 735–766, 1929.

MUCKERMANN, HERMAN. Wesen der Eugenik und Aufgaben der Gegenwart. *Das Kommende Geschlecht*, Band V, Heft 1/2, pp. 1–48, 1929.

OSBORN, HENRY FAIRFIELD. The discovery of tertiary man. *Science*, Vol. LXXI, No. 1827, pp. 1–7, 1930.

PARKER, G. H. Heredity and human biology. *Annals of Otology, Rhinology and Laryngology*, Vol. XXXVIII, No. 4, p. 940, 1929.

PEI, W. C. An account of the discovery of an adult *Sinanthropus* skull in the Chou Kou Tien deposit. *Bulletin of the Geological Society of China*, Vol. VIII, pp. 203–205, 1929.

SAVILLE, MARSHALL H. Tizoc, Great Lord of the Aztecs, 1481–1486. Contributions from the Museum of the American Indian. Heye Foundation, Vol. VII, No. 4. *New York* (Museum of the American Indian, Heye Foundation), 1929. Pp. 78. 6¾ × 10 inches. $1.60 (paper).

SHIPLEY, MAYNARD. The Key to Evolution. In Four Double Volumes. Vol. 1, How Life Began. Vol. 2, How Plants Arose. Vol. 3, The Origin of Animals. Vol. 4, The Origin of the Backboned Animals. Vol. 5, From Amphibian to Man. Vol. 6, Man, Cousin to the Apes. Vol. 7, Embryology and Evolution. Vol. 8, Causes and Methods of Evolution. *Girard, Kansas* (Haldeman-Julius Co.), 1930. Pp. 64 in each double volume. 5½ × 8½ inches. $2.45, prepaid, for set of four double volumes.

SIEMENS, HERMANN W. Grundzüge der Vererbungslehre, Rassenhygiene und Bevölkerungspolitik für Gebildete aller Berufe. *München* (J. F. Lehmanns Verlag), 1930. Pp. 147. 4⅞ × 7½ inches. 3 marks (paper); 4 marks (cloth).

UNIVERSITY OF VERMONT. Fourth Annual Report of the Eugenics Survey of Vermont. March, 1930. (Office of the Survey, 138 Church St., Burlington, Vermont.) 40 pp.

v. VERSCHUER, O. Erbpsychologische Untersuchungen an Zwillingen. *Zeitschrift für induktive Abstammungs- und Vererbungslehre*, Band LIV, pp. 280–285, 1930.

WALTER, HERBERT E. Genetics. An Introduction to the Study of Heredity. *New York* (The Macmillan Co.), 1930. Pp. xxi + 359. 4⅞ × 7¼ inches. $2.50.

WOLBARST, A. L. Generations of Adam. *New York* (Newland Press), 1930. Pp. ix + 355. 5½ × 8 inches. $3.50.

II. GROUP BIOLOGY

BELZ, M. H. Theories of population and their application to Australia. I. The logistic law of population increase. II. Cycles and the logistic law. III. Application to Australia. IV. Application to New South Wales. V. Application to Tasmania. *The Economic Record*, November, 1929, pp. 253–262.

BLOODGOOD, JOSEPH COLT. Cancer as a public health problem. *Indianapolis Medical Journal*, Vol. XXXII, No. 10, pp. 605–607, 1929.

BLOODGOOD, JOSEPH COLT. Cancer as a world problem. *Indianapolis Medical Journal*, Vol. XXXII, No. 12, pp. 746–748, 1929; and *New York State Journal of Medicine*, March 1, 1930, 14 pp.

BLOODGOOD, JOSEPH COLT. The evidence of the value of education in the control of cancer. *Indianapolis Medical Journal*, Vol. XXXII, No. 7, pp. 391–395, 1929.

BLUNCK, H. Der Kampf der Landwirtschaft gegen die zunehmenden Pflanzenkrankheiten. *Landwirtschaftliches Wochenblatt für Schleswig-Holstein*, 79. Jahrg., Nr. 51, pp. 1201–1206 und Nr. 52, pp. 1227–1230, 1929.

BUREAU OF THE CENSUS. Religious Bodies: 1926. Volume II. Separate Denominations. Statistics, History, Doctrine, Organization, and Work. *Washington* (U. S. Government Printing Office), 1929. Pp. xiii + 1405. 5¾ × 9 inches. $2.00.

BUREAU OF COMMERCIAL FISHERIES STAFF. The commercial fish catch of California for the year 1928. California Division of Fish and Game. Fish Bulletin No. 20. (Sacramento, Cal.), 110 pp., 1930.

CANADA. Sixth Census of Canada, 1921. Volume IV—Occupations. *Ottawa* (F. A. Acland), 1929. Pp. cxlvii + 837. 6½ × 9¾ inches. $1.00 (paper).

COLLINS, SELWYN D. The influenza epidemic of 1928–1929 with comparative data for 1918–1919. *American Journal of Public Health*, Vol. XX, No. 2, pp. 119–129, 1930.

COMMITTEE ON IMMIGRATION AND NATURALIZATION. Western Hemisphere Immigration. Hearings before the Committee on Immigration and Naturali-

zation, House of Representatives. Seventy-first Congress, Second Session, on the Bills H.R. 8523, H.R. 8530, H.R. 8702, to Limit the Immigration of Aliens to the United States, and for other purposes. *Washington* (Government Printing Office), 1930. Pp. iii + 457.

COMMITTEE OF NEIGHBORHOOD HEALTH DEVELOPMENT. Proposed Health Districts, New York City. Statistical reference data. District populations; school children; births; tuberculosis and contagion registration; local mortality. *New York City Department of Health*, March, 1930. 28 pp.

DROLET, G. J. Epidemiology of tuberculosis in New York City. Recent changes in the death rate at various age periods, particularly among women and children. *Journal of Preventive Medicine*, Vol. 4, pp. 115–138, 1930.

DUBLIN, LOUIS I. The job and the life span. *Harper's Monthly Magazine*, January, 1930, 10 pp.

DUBLIN, LOUIS I., and ALFRED J. LOTKA. The Money Value of a Man *New York* (The Ronald Press Co.), 1930. Pp. xv + 264. 5⅝ × 8⅜ inches. $5.00.

DUBLIN, LOUIS I., and ROBERT J. VANE, JR. Causes of Death by Occupation. Occupational Mortality Experience of the Metropolitan Life Insurance Company, Industrial Department, 1922–1924. Bulletin of the United States Bureau of Labor Statistics No. 507. *Washington* (U. S. Government Printing Office), 1930. Pp. iv + 130. 5¾ × 9⅛ inches. 25 cents (paper).

FEGIZ, P. LUZZATTO. La Popolazione di Trieste (1875–1928). *Trieste* (Istituto Statistico-Economico), 1929. Pp. 106. 9½ × 13¼ inches.

FRY, C. LUTHER. The U. S. Looks at Its Churches. *New York* (Institute of Social and Religious Research), 1930. Pp. xiv + 183. 6 × 9 inches. $2.50.

GREENWOOD, MAJOR. The periodicity of influenza. *Journal of Hygiene*, Vol. XXIX, No. 3, pp. 227–235, 1930.

HARPER, ROLAND M. Some demographic characteristics of American educational centers. *Scientific Monthly*, Vol. XXX, pp. 164–169, 1930.

HARPER, ROLAND M. Some neglected aspects of the immigration problem. Statistical comparisons of native and foreign whites, and natives of foreign and mixed parentage, in the United States. *Eugenics*, Vol. II, No. 10, pp. 24–34; No. 11, pp. 22–30, 1929.

HARPER, ROLAND M. A statistical study of the aristocracy of Athens. *Athens (Georgia) Banner-Herald*, Jan. 12, 1930. 4 pp.

HERSKOVITS, MELVILLE J. Race relations in the United States, 1928. *American Journal of Sociology*, Vol. XXXIV, No. 6, pp. 1129–1139, 1929.

HIMES, NORMAN E. Robert Dale Owen, the pioneer of American Neo-Malthusianism. *American Journal of Sociology*, Vol. XXXV, No. 4, pp. 529–547, 1930.

HIMES, NORMAN E. Some untouched birth control research problems. *Eugenics*, Vol. III, No. 2, pp. 1–8, 1930.

HOFFMAN, FREDERICK L. The homicide record for 1929. Prohibition a contributing factor to growing insecurity of human life in America where violent deaths are more common than anywhere else in the world. 4 pp. (No place, publisher, or date given.)

JENKINS, THOMAS A., and JOHN C. BOX. Immigration from Countries of the Western Hemisphere. Hearings before the Committee on Immigration and Naturalization, House of Representatives, Seventy-first Congress, second session, on H.R. 8523, H.R. 8530, H.R. 8702. Hearing No. 21.2.11. Extracts containing statements of Hon. Thomas A. Jenkins, Hon. John C. Box. *Washington* (U. S. Government Printing Office), March 14, 1930. Pp. 587–607.

MANNING, CAROLINE. The Immigrant Woman and Her Job. Bulletin of the Women's Bureau No. 74. *Washington* (U. S. Government Printing Office), 1930. Pp. ix + 179. $5\frac{3}{4} \times 9\frac{1}{8}$ inches. 30 cents (paper).

DE MELLO, F. FIGUEIRA, Director. O Brasil de Amanhã. Divulgação de Hygiene Publicação N. 7, 116 pp., 1929.

MILBANK MEMORIAL FUND (49 Wall St., New York City). The New York health demonstrations. Current Reports by the Directors of the demonstrations. April 15, 1930. 9 pp.

MOOREHOUSE, G. W. Age distribution of influenza deaths, Cleveland, Ohio, 1918–1929. *American Journal of Hygiene*, Vol. XI, No. 1, pp. 196–201, 1930.

MUCKERMANN, HERMANN. Neue Forschungen über das Problem der differenzierten Volksvermehrung. *Zeitschrift für induktive Abstammungs- und Vererbungslehre*, Band LIV, pp. 287–295, 1930.

RIETZ, H. L. Pensions for superannuated employees. *Scientific Monthly*, Vol. XXX, pp. 224–231, 1930.

ROBERTSON, T. BRAILSFORD. The duration of life. *Report Australian Association for the Advancement of Science*, Vol. XVIII, pp. 863–882, 1926.

SACHAR, ABRAM LEON. A History of the Jews. *New York* (Alfred A. Knopf, Inc.), 1930. Pp. xli + 408. $6\frac{1}{4} \times 9\frac{1}{4}$ inches. $5.00.

SANDERS, J. Comparative Birth-rate Movements Among European Nations. A comparison of both the crude birth-rate, the birth-rate per 1000 females 15 to 45 years of age, and the "vital index" (or $\frac{100 \text{ births}}{\text{deaths}}$ ratio) of the Nordic peoples and the non-Nordic peoples of Europe. Eugenics Research Association Monograph Series No. 1. *Cold Spring Harbor, Long Island, N. Y.* (Eugenics Research Association), 1929. Pp. viii + 126. 6×9 inches. $1.50.

SARAO, FELIX B. The cost of producing milk at the College of Agriculture. *Philippine Agriculturalist*, Vol. XVIII, No. 7, pp. 427–438, 1929.

SEAGAR, E. A. Labour efficiency. A preliminary statement of relativity of factors adversely affecting the efficiency of agricultural labourers. *Tropical Agriculture*, Vol. VII, No. 2, pp. 40–45, 1930.

Souza-Araujo, H. C. de. Leprosy. Survey Made in Forty Countries (1924–1927). *Rio de Janeiro* (Oswaldo Cruz Institute), 1929. Pp. 400. 7½ × 11¼ inches. $4.00 (paper). (May be obtained from D. Appleton, New York; W. B. Saunders Co., Philadelphia; Cassel and Co., London; Masson et Cie, Paris; The Macmillan Co., of Canada, Toronto. The total revenue of the Portuguese and English issues is reserved to form the fund of the *Societas Internationalis Leprologiae*, of Bergen, Norway.)

Terceiro Congresso Brasileiro de Hygiene. Realizado em São Paulo de 4 a 12 de Novembre, 1926. *São Paulo Editora Ltda., Rua Brigadeiro Tobias*, Nos. 78–80. Pp. 1–938, 1929.

United States Department of Labor, Children's Bureau. Child Labor. Facts and Figures. Bureau Publication No. 197. *Washington* (U. S. Government Printing Office), 1930. Pp. viii + 133. 5¾ × 9⅛ inches. 25 cents (paper).

Wadsworth, James W., Jr. The death toll of enforcement. *North American Review*, March, 1930. 7 pp.

Walch, E. W. Het goed recht der hygiëne, hare toepassing in Nederlandsch-Indië. Rede uitgesproken bij de aanvaarding van het Hoogleeraarsambt aan de Geneeskundige Hoogeschool te Batavia op 28 Maart, 1930. 38 pp.

III. BEHAVIOR

Abbot, Charles Greeley. Biographical memoir of Henry Larcom Abbot, 1831–1927. *Biographical Memoirs, National Academy of Sciences*, Vol. XIII (First Memoir), pp. 1–101, 1929.

Abbott, Grace. Case work responsibility of juvenile courts. *Proceedings of the National Conference of Social Work*, pp. 153–162, 1929.

Alexander, Franz. Authorized English translation by Bernard Gleuck and Bertram D. Lewin. With a prefatory note by A. A. Brill. The Psychoanalysis of the Total Personality. The Application of Freud's Theory of the Ego to the Neuroses. *New York and Washington* (Nervous and Mental Disease Publishing Co.), 1930. Pp. xx + 176. 6 × 9 inches. $3.50.

Association Against the Prohibition Amendment. Annual report to the directors, members and friends of the Association Against the Prohibition Amendment. Submitted by the Executive Committee of the Board of Directors for the Year 1929. *Association Against the Prohibition Amendment* (21 E. 40th St., New York City). Pp. 1–31.

Bacon, Selden. The X Amendment. Its supreme importance and its effect on the XVIII Amendment. 40 pp. (No place of publication; no date. Distributed in 1930.)

Burke, Dorothy Williams. Youth and Crime. A Study of the Prevalence and Treatment of Delinquency Among Boys Over Juvenile-Court Age in Chicago. United States Department of Labor. Children's Bureau Publication No. 196. *Washington* (U. S. Government Printing Office), 1930. Pp. v + 205. 5¾ × 9⅛ inches. 35 cents (paper).

BURROW, TRIGANT. The physiological basis of neurosis and dream. A societal interpretation of the sensori-motor reactions reflected in insanity and crime. *Journal of Social Psychology*, Vol. 1, No. 1, pp. 48–65, 1930.

CALVERT, P. P A graduate student I? *General Magazine and Historical Chronicle*, University of Pennsylvania, April, 1928. 11 pp.

CASSELLARI, RENÉ. Dramas of French Crime. Being the Exploits of the Celebrated Detective René Cassellari. *London* (Hutchinson and Co., Ltd.), 1930. Pp. 288. 6 × 9 inches. 18 shillings net.

COE, WESLEY R. Biographical memoir of Sidney Irving Smith, 1843–1926. *Biographical Memoirs, National Academy of Sciences*, Vol. XIV (First Memoir), pp. 1–16, 1929.

FISCHER, MAX. Der Alkoholmissbrauch. *Das kommende Geschlecht*, Band IV, Heft 3, pp. 1–72. (No date.)

FRANKEL, LEE K. Cost of medical care. *Committee on the Cost of Medical Care* (Washington) 11 pp., 1930.

HEINLEIN, JULIA H. Preferential Manipulation in Children. Comparative Psychology Monographs, Vol. 7, No. 3, Serial No. 33. *Baltimore* (The Johns Hopkins Press), 1930. Pp. 121. 7 × 10 inches. $1.75 (paper).

HERSKOVITS, MELVILLE J. The Negro and the Intelligence Tests. *Hanover, N. H.* (Sociological Press), 1927. Pp. 14. 6 × 9 inches. 10 cents (paper).

HERSKOVITS, MELVILLE J. Preliminary report of an ethnological expedition to Suriname, 1928. *De Wist-Indische Gids*, pp. 385–390. (Martinus Nijhoff, The Hague.)

HERSKOVITS, MELVILLE J. Wisdom from Africa. *The Crisis*, September, 1929, pp. 306–307.

HERSKOVITS, MELVILLE J., and MORRIS J. ROGERS, JR. A note on present day myth. *Journal of American Folk-Lore*, Notes and Queries, pp. 73–75, 1930.

HUDSON, MANLEY O. The eighth year of the Permanent Court of International Justice. *International Conciliation*, No. 259. April, 1930, pp. 193–229. 5 cents (Carnegie Endowment for International Peace, 44 Portland St., Worcester, Mass.).

INSTITUTE OF LAW, JOHN HOPKINS UNIVERSITY. The contribution of the practicing lawyer to a realistic study of the administration of justice. 11 pp. 1930.

INSTITUTE OF LAW, JOHNS HOPKINS UNIVERSITY. Outline statement concerning state-wide studies of judicial administration. 11 pp. 1930.

JENNINGS, H. S. The Biological Basis of Human Nature. *New York* (W. W. Norton and Co., Inc.), 1930. Pp. xviii + 384. 5¾ × 8½ inches. $4.00.

JOHNS HOPKINS HOSPITAL. Dedication of the Wilmer Institute, October 15 and 16, 1929. 88 pp., 1929.

JOHNSTON, ALEX. The Life and Letters of Sir Harry Johnston. *New York* (Jonathan Cape and Harrison Smith), 1929. Pp. 351. 5¼ × 8 inches. $3.50.

JONES, THOMAS E. Progress at Fisk University. A summary of recent years. *Nashville, Tenn.* (Fisk University), 1930. Pp. vii + 55.

JOY, HENRY B.; Compiled by. Appeal to President Coolidge's "Court of Last Resort." In defense of the Constitution of the United States and the Bill of Rights. Against the XVIIIth Amendment. 2766 *Penobscot Bldg., Detroit, Michigan* (Henry B. Joy). 141 pp. 1930.

JUDICIAL COUNCIL OF OHIO, THE OHIO STATE BAR ASSOCIATION, THE INSTITUTE OF LAW OF THE JOHNS HOPKINS UNIVERSITY. Facts and the administration of justice. Interim statement—study of judicial administration in Ohio, Bulletin No. 3. 29 pp. 1930.

JUDICIAL COUNCIL OF OHIO, OHIO STATE BAR ASSOCIATION, THE INSTITUTE OF LAW OF THE JOHNS HOPKINS UNIVERSITY. Judicial statistics. Interim statement—study of judicial administration in Ohio. Bulletin No. 2. 21 pp. 1930.

JUDICIAL COUNCIL OF OHIO, THE OHIO STATE BAR ASSOCIATION, THE INSTITUTE OF LAW OF THE JOHNS HOPKINS UNIVERSITY. A study of the administration of justice in Ohio. Statement of the immediate program. 8 pp. 1930.

JUDICIAL COUNCILS AND MEMBERS OF THE INSTITUTE OF LAW OF THE JOHNS HOPKINS UNIVERSITY. Conference on studies in the administration of justice. Held at Mayflower Hotel, Washington, May 7, 1930. 12 pp.

KILPATRICK, GEORGE. Prohibition and the Bible. 824 *Ford St., Bridgeport, Pa.*, (George Kilpatrick), 1928. Pp. 23. 3½ × 6 inches. 15 cents (paper).

LOVEJOY, ARTHUR O. The Revolt Against Dualism. An Inquiry Concerning the Existence of Ideas. *New York* (W. W. Norton and Co.), 1930. Pp. xii + 325. 6 × 9 inches. $4.00.

LYMAN, FREDA RING. Analysis and Tabular Summary Relating to Jurisdiction in Children's Cases and Cases of Domestic Relations in the United States. U. S. Department of Labor, Children's Bureau, Chart No. 17. *Washington* (U. S. Government Printing Office), 1930. Pp. v + 33. 9 × 11¾ inches. 10 cents (paper).

MCFADDEN, LOUIS T. Inte rnational bank of settlements. Remarks of Hon. Louis T. McFadden of Pennsylvania in the House of Representatives February 10, 1930. *Washington* (U. S. Government Printing Office), 1930. Pp. 1–15.

MONEY-KYRLE, R. The Meaning of Sacrifice. Thesis Approved for the Degree of Doctor of Philosophy in the University of London. The International Psycho-Analytical Library No. 16. *London* (The Hogarth Press), 1930. Pp. 273. 6¼ × 9½ inches. 18 shillings.

MORTARA, GIORGIO. Prospettive Economiche. VIII. *Milano* (Università Bocconi di Milano), 1930. Pp. xxiii + 551. 7 × 10 inches.

NINTH INTERNATIONAL CONGRESS OF PSYCHOLOGY. Held at Yale University, New Haven, Connecticut, September 1st to 7th, 1929, under the Presidency of James McKeen Cattell. Proceedings and Papers. *Princeton, N. J.* (The Psychological Review Co.), 1930. Pp. xli + 534. 7 × 10¼ inches. $5.25.

OSBORN, HENRY FAIRFIELD. Biographical memoir of Edward Drinker Cope, 1840–1897. *Biographical Memoirs, National Academy of Sciences*, Vol. XIII (Third Memoir). Pp. 125–317, 1930.

PAGE, LEIGH. Biographical memoir of Henry Andrews Bumstead, 1870–1920. *Biographical Memoirs, National Academy of Sciences*, Vol. XIII (Second Memoir). Pp. 102–124, 1929.

PARKER, G. H. Kim Kurmah, or what are we about? *Scientific Monthly*, Vol. XXX, February, 1930, pp. 97–106.

PARKHURST, WINTHROP. The Anatomy of Music. A Complete Popular Outline of Musical Theory. *New York* (Alfred A. Knopf, Inc.), 1930. Pp. xix + 200. 5⅛ × 7½ inches. $2.50.

PARSHLEY, H. M. Science and pantheism. *Freeman*, March 22, 1930. 3 pp.

PHILLIPS, THOMAS W., JR. The Bible versus Prohibition. Search the Scriptures and determine whether the things herein set forth are so. 32 pp. *Butler, Pa.* (Thomas W. Phillips, Jr.), 1930.

RODRIGUEZ, GERMINAL. Un Año de Accion Comunal. *"Partido Socialista Independiente" Buenos Aires* (Gmo. Kraft, Ltda.), 1929. Pp. 185.

SHAW, RALPH M. The Eighteenth Amendment It has not been enforced; it is not being enforced; it never can be enforced. Statement before the Judiciary Committee of the House of Representatives on the Twentieth Day of February, 1930. (No place of publication.)

TAFT, HON. WILLIAM H. The XVIIIth Amendment. Statements relative, and resolutions favoring its repeal by the Bar Associations of New York City, Philadelphia, Boston, San Francisco. *Detroit, Mich.* (Henry B. Joy). 16 pp., 1930.

TAYLOR, GRIFFITH. Antarctic Adventure and Research. *New York* (D. Appleton and Co.), 1930. Pp. xi + 245. 5 × 7⅜ inches. $2.00.

THOM, HELEN HOPKINS. Johns Hopkins. A Silhouette. *Baltimore* (The Johns Hopkins Press), 1929. Pp. xi + 125. 6 × 9 inches. $2.75.

TITCHENER, EDWARD B. Systematic Psychology: Prolegomena. *New York* (The Macmillan Co.), 1929. Pp. xi + 278. 4⅞ × 7⅜ inches. $2.50.

TURNBULL, H. W. The Great Mathematicians. *London* (Methuen and Co., Ltd.), 1929. Pp. viii + 128. 4⅛ × 6⅞ inches. 2s. 6d.

UNITED STATES DEPARTMENT OF LABOR, CHILDREN'S BUREAU. Juvenile Delinquency in Maine. *Washington* (U. S. Government Printing Office), 1930. Pp. v + 90. 5¾ × 9 inches. 15 cents (paper).

VERY, SAMUEL R. T. Sobriety and reason. A synopsis of proposed legislation. Samuel R. T. Very (100 East 45th St., New York City), February, 1930, 4 pp.

THE WILLIAM H. WELCH MEDICAL LIBRARY of The Johns Hopkins University. An account of its origin and development, together with a description of the building, and an account of the exercises held on the occasion of the dedication of the Library and the inauguration of the chair of the History of Medicine at The Johns Hopkins University, Baltimore, Maryland, October 17 and 18, 1929. *Bulletin of the Johns Hopkins Hospital*, Vol. XLVI, No. 1, vii + 153 pp. January, 1930.

IV. SOMATOLOGY AND CONSTITUTION

ELWYN, ADOLPH. Yourself, Inc. The Story of the Human Body. *New York* (Brentano's), 1930. Pp. iv + 320. 5¾ × 8⅜ inches. $3.50.

FISCHER, E. Bericht über die Tätigkeit des Ausschusses für Varietätenforschung. *Verhandlungen der Anatomischen Gesellschaft. Ergänzungsheft zum Anatomischen Anzeiger*, Bd. 67, pp. 247–248. 1929.

FISCHER, E. Zur Frage der Zwillingsbildung beim Nagetier (Ein Fall von Duplicitas posterior). *Wilhelm Roux' Archiv für Entwicklungsmechanik der Organismen*, Band 118, pp. 352–358, 1929.

HARRIS, H. A., S. H. GRAY and CAROLINE WHITNEY. The heart of a child aged twenty-two months presenting an anomalous vein from the pulmonary auricle to the right internal jugular vein, transposition of the great vessels and left superior vena cava. *Anatomical Record*, Vol. 36, pp. 31–49, 1927.

HELLMAN, MILO. The orbital plane. Its relation to dentitions of different races, to dentitions in the course of development, and to dentitions in malocclusion. *International Journal of Orthodontia, Oral Surgery and Radiography*, Vol. XVI, No. 2, p. 151, 1930.

KLENCK, WILHELM, and WALTER SCHEIDT. Niedersächsische Bauern. I. Geestbauern im Elm-Weser-Mündungsgebiet (Börde Lamstedt). *Jena* (Gustav Fischer), 1929. Pp. ix + 112 + 8 tables. 6¾ × 10⅛ inches. 8 marks (paper); 9.50 marks (cloth).

MACDONALD, ARTHUR. Legislative anthropology. *The Johns Hopkins Alumni Magazine*, Vol. XVII, No. 3, pp. 254–250, 1929.

MANREDA, MIGUEL, and VALENTE VILLEGAS. A note on the capacity and other measurements of the alimentary tract of an Indian Buffalo cow. *Philippine Agriculturist*, Vol. XVIII, No. 10, pp. 605–607, 1930.

NELSON, LOUISE A. Variations in Development and Motor Control in Goiterous and Non-goiterous Adolescent Girls. *Baltimore* (Warwick and York, Inc.), 1929. Pp. xii + 193. 5⅛ × 7⅝ inches. $2.75 + 10¢ postage.

PARKER, G. H. The neurofibril hypothesis. *Quarterly Review of Biology*, Vol. IV, No. 2, pp. 155–178, 1929.

SCHULTZ, ADOLPH H. The promise of a youthful science. *John Hopkins Alumni Magazine*, Vol. XVIII, No. 3, pp. 185–206, 1930.

SHUMWAY, WALDO. Vertebrate Embryology. A Textbook for Colleges and Universities. *New York* (John Wiley and Sons, Inc.), 1930. Pp. x + 311. 5⅞ × 9 inches. $3.75 net.

v. VERSCHUER, O., and V. ZIPPERLEN. Die erb- und unweltbedingte Variabilität der Herzform (Nach Röntgenfernaufnahmen des Herzens bei Zwillingen). *Zeitschrift für klinische Medizin*, Band 112, Heft 1 und 2, pp. 69–92. 1929.

WATERMAN, HARRIET C. Studies on the Evolution of the Pelvis of Man and Other Primates. Bulletin of the American Museum of Natural History. Vol. LVIII, Art. XII. *New York* (American Museum of Natural History), 1929. Pp. 58. 6¼ × 9½ inches. 65 cents (paper).

WIEMAN, H. L. An Introduction to Vertebrate Embryology. *New York* (McGraw-Hill Book Co., Inc.), 1930. Pp. xi + 411. 5¾ × 9 inches. $4.00.

ZAND, NATHALIE. Les Plexus Choroides. Anatomie, Physiologie, Pathologie. *Paris* (Masson et Cie), 1930. Pp. viii + 140. 6½ × 10 inches. 22 francs (paper).

V. PHYSIOLOGY

CAMPBELL, J. ARGYLL. Living at very high altitudes and maintenance of normal health. *Lancet*, Vol. CCXVIII, p. 370, 1930.

FEARING, FRANKLIN. Reflex Action. A Study in the History of Physiological Psychology. *Baltimore* (The Williams and Wilkins Co.), 1930. Pp. xiv + 350. 6 × 9 inches. $6.50.

HANDBUCH DER BIOLOGISCHEN ARBEITSMETHODEN, Lieferung 322. Containing the following articles: Methoden zur Untersuchung des Energieumsatzes in Muskeln und Nerven, by J. L. Parkinson; Die Arbeitsmaschine Johanssons, by Ernest Abramson. *Berlin* (Urban und Schwarzenberg), 1930. Pp. 116. 7 × 10 inches. 7 marks (paper).

HOLMES, ARTHUR D., and HANNA L. ACKERMAN. The value of cod liver oil for underpar children of school age. *New England Journal of Medicine*, Vol. 202, No. 10, pp. 470–476, 1930.

LARTIGUE, ALFRED. Biodynamique Générale Fondée sur l'Étude du Tourbillon Vital d'Éther. *Paris* (Gaston Doin et Cie), 1930. Pp. iv + 156. 5⅝ × 9⅛ inches. 20 francs (paper).

LIDDELL, E. G. T., and SIR CHARLES SHERRINGTON. Mammalian Physiology. A Course of Practical Exercises. A New Edition. *New York* (Oxford University Press), 1929. Pp. xii + 162. 8 × 10⅞ inches. $4.00.

LOEB, LEO. The mechanism in the development of pulmonary edema. *Proceedings of the Society for Experimental Biology and Medicine*, Vol. XXV, pp. 321–323, 1928.

MATLA, J. L. W. P. La Solution du Mystère de la Mort. *Paris* (Gaston Doin et Cie), undated. 6¼ × 9½ inches. Pp. vi + 284 + 6 plates. 65 francs (paper); 75 francs (cloth).

MONGE, CARLOS. Les Érythrémies de l'Altitude. Leurs Rapports avec la Maladie de Vaquez. Études Physiologique et Pathologique. *Paris* (Masson et Cie), 1929. Pp. xi + 135. 6⅜ × 10 inches. 22 francs (paper).

PARKES, A. S. The Internal Secretions of the Ovary. *New York* (Longmans, Green and Co.), 1929. Pp. xv + 242. 5¾ × 8⅝ inches. $7.50.

PARSONS, T. R. The Materials of Life. A General Presentation of Biochemistry. *New York* (W. W. Norton and Co., Inc.), 1930. Pp. 288. 5¾ × 8¼ inches. $3.00.

ROBERTSON, T. BRAILSFORD, and M. C. DAWBARN. Preliminary communication on the influence of age of the animal upon the nucleic acid and coagulable nitrogen content of the tissues of sheep. *Australian Journal of Experimental Biology and Medical Science*, Vol. VI, pp. 261–275, 1929.

SAYERS, R. R., and SARA J. DAVENPORT. Review of carbon monoxide poisoning. Public Health Bulletin No. 195. *Washington* (U. S. Government Printing Office), 1930. Pp. iii + 97. 5¾ × 9⅛ inches. 20 cents (paper).

SCARTH, G. W., and F. E. LLOYD. An Elementary Course in General Physiology. Part I—Principles and Theory, by G. W. Scarth. Part II—Laboratory Exercises, by F. E. Lloyd and G. W. Scarth. *New York* (John Wiley and Sons, Inc.), 1930. Pp. xxi + 258. 5¾ × 9 inches. $2.75.

SEAGAR, E. A. Defective diet. Notes on the feeding of indigenous rats on tannia and other tubers, with special reference to the question of toxic effects. *Tropical Agriculture*, Vol. VII, pp. 120–122, 1930.

SHAW, J. J. M. The Cancer Process. An Examination of the Factors which Induce New Growth. *Edinburgh* (E. and S. Livingstone), 1930. Pp. 16. 5¾ × 9 inches. 1 shilling net (paper).

SNYDER, HARRY. Bread. A Collection of Popular Papers on Wheat, Flour and Bread. (With a Biographical Sketch of the Author by Andrew L. Winton.) *New York* (The Macmillan Co.), 1930. Pp. x + 293. 5⅛ × 7¾ inches. $2.50.

SWANSON, EDWARD E. I. The action of ephedrine, pseudoephedrine and epinephrine on the bronchioles. *Journal of Pharmacology and Experimental Therapeutics*, Vol. XXXVI, No. 4, pp. 541–568, 1929.

SWANSON, EDWARD E. A study of the pressor method for the standardization of pituitary extract. *Journal of Laboratory and Clinical Medicine*, Vol. XIV, p. 754, 1929.

SWEENEY, J. SHIRLEY. Endocrinology in eye, ear, nose and throat practice. *Texas State Journal of Medicine*, October, 1929. 10 pp.

TERROINE, ÉMILE F. L'Institut de Physiologie Générale de la Faculté des Sciences de l'Université de Strasbourg. *Strasbourg* (Société des Amis de l'Université), 1929. 30 pp.

TERROINE, ÉMILE F., and R. BONNET. Utilisation par l'organisme de l'énergie libérée par les oxydations et le problème de la valeur alimentaire de l'alcool. *Bulletin de la Société de Chimie Biologique*, Tome XI, pp. 1123–1253, 1929.

TERROINE, ÉMILE F., and L. MELON. Influence de l'anesthésie sur la grandeur des échanges chez les Homéothermes à neutralité thermique. *Annales de Physiologie et de Physicochimie Biologique*, No. 4, p. 557, 1927.

TERROINE, ÉMILE F., and CH. RITTER. Le métabolisme de base est-il fonction de la grandeur de la masse active représentée par les substances nucléiniques? *Annales de Physiologie et de Physicochimie Biologique*, No. 4, p. 575, 1927.

THEWLIS, MALFORD W. Geriatrics. A Treatise on the Prevention and Treatment of Diseases of Old Age and the Care of the Aged. *St. Louis* (The C. V. Mosby Co.), 1924. Pp. 401. 6 × 9 inches. $4.50.

VI. PATHOLOGY

BELL, W. BLAIR (Edited by). Some Aspects of the Cancer Problem. An Account of Researches into the Nature and Control of Malignant Disease Commenced in the University of Liverpool in 1905, and Continued by the Liverpool Medical Research Organization (Formerly the Liverpool Cancer Committee), together with some of the Scientific Papers that have been Published. *New York* (William Wood and Co.), 1930. Pp. xiv + 543. 7¼ × 10 inches. $20.00.

BESREDKA, A. Antivirusthérapie. Application à l'Ophthalmologie, à l'Oto-Rhino-Laryngologie, à la Stomatologie, à l'Entérologie, à l'Urologie, la Gynécologie et l'Obstétrique, les Pyodermites, la Chirurgie, la Médecine Vétérinaire, la Sérotherapie locale. *Paris* (Masson et Cie), 1930. Pp. viii + 430. 5⅝ × 9 inches. 40 francs (paper).

BESREDKA, A. Immunity in Infectious Diseases. A Series of Studies. (Authorized Translation by Herbert Child.) *Baltimore* (The Williams and Wilkins Co.), 1930. Pp. vii + 364. 5½ × 8½ inches. $5.00.

BLOODGOOD, JOSEPH COLT. Cancer of bone in children and how to prevent crippling. *Indianapolis Medical Journal*, Vol. XXXI, No. 12, pp. 343–344, 1928.

BLOODGOOD, JOSEPH COLT. Non-cancerous diseases of bone in children and how to prevent crippling. *Indianapolis Medical Journal*, Vol. XXXI, No. 12, pp. 345–347, 1928.

BLOODGOOD, JOSEPH COLT. The three problems in cancer control. *Indianapolis Medical Journal*, Vol. XXXII, No. 2, pp. 63–66, 1929.

BLOODGOOD, JOSEPH COLT. What every adult man and woman should know about cancer. *Indianapolis Medical Journal*, Vol. XXXII, No. 9, pp. 532–534, 1929.

BLOODGOOD, JOSEPH COLT. What every high school boy or girl should know about cancer, and other diseases and conditions which interfere with health and which may cause death, when there is ignorance or neglect in the beginning. *Indianapolis Medical Journal*, Vol. XXXII, No. 8, pp. 460–464, 1929.

COMMUNICATIONS DE L'INSTITUT SÉROTHÉRAPIQUE DE L'ÉTAT DANOIS. Tome XX. (Acta Pathologica et Microbiologica Scandinavica. Supplementum III.) *Copenhagen* (Levin and Munksgaard), 1930. Pp. 561.

FRETS, G. P. Drie gevallen van cronische encephalitis epidemica en het pathologisch-anatomisch onderzoek. *Nederl. Tijdschrift voor Geneeskunde*, Jahr. 74, pp. 484–497, 1930.

FRETS, G. P. Een geval van psychose bij endarteriitis luetica van de kleine bloedvaten van de hersenen. *Psychiatrische en Neurologische Bladen*, Jahr. 1929, No. 6, 7 pp.

GRAY, S. H. Spontaneous rupture of the spleen following venous thrombosis in carcinoma of the pancreas. *Archives of Pathology*, Vol. 6, pp. 433–435, 1928.

HEGNER, ROBERT. *Endolimax amoeba* in the vagina of rhesus monkeys. *Journal of Parasitology*, Vol. XVI, pp. 91–92, 1929.

HEGNER, ROBERT. The infection of parasite-free chicks with intestinal protozoa from birds and other animals. *American Journal of Hygiene*, Vol. X, No. 1, pp. 33–62, 1929.

HEGNER, ROBERT. Transmission of intestinal protozoa from man and other animals to parasite-free fowls. *American Journal of Hygiene*, Volume IX, No. 3, pp. 529–543, 1929.

KNOPF, S. ADOLPHUS. Effects of cigarette smoking on tuberculosis among young women, on the child in utero and in early life, and on certain conditions and diseases in adults. *Medical Journal and Record*, Nov. 6, 1929. 16 pp.

KOUNTZ, W. B., and H. L. ALEXANDER. Death from bronchial asthma. Report of three cases. *Archives of Pathology*, Vol. 5, pp. 1003–1019, 1928.

LAYANI, FERNAND. Les Acrocyanoses. Troubles vasculaires cutanés d'origine nerveuse, végétative ou centrale. *Paris* (Masson et Cie), 1929. Pp. iv + 282. 6¼ × 9½ inches. 32 francs (paper).

MASTERS, J. M., LEON G. ZERFAS, and HOWARD B. METTEL. Congenital hemolytic icterus. Treatment of splenectomy; reports of two cases. *American Journal of Diseases of Children*, Vol. 37, pp. 1254–1259, 1929.

TOPLEY, W. W. C., and G. S. WILSON. The Principles of Bacteriology and Immunity. In two volumes. *New York* (William Wood and Co.), 1929. Pp. xliv + 1300. 6½ × 9½ inches. $15.00 net per set.

WOLFRAM, E. The Occult Causes of Diseases. Being a Compendium of the Teachings Laid Down in His "Volumen Paramirum" by Bombastus von Hohenheim, Better Known as Paracelsus. Done into English by Agnes Blake. *London* (Rider and Co.), 1930. Pp. 296. 4⅞ × 7⅜ inches. 6 shillings.

VII. METHODOLOGY

BELLING, JOHN. The Use of the Microscope. A Handbook for Routine and Research Work. *New York* (McGraw-Hill Book Co., Inc.), 1930. Pp. xi + 315. 5¾ × 9 inches. $4.00.

BERKSON, JOSEPH. Bayes' Theorem. *Annals of Mathematical Statistics*, Vol. I, No. 1, pp. 42–56, 1930.

FRISCH, R. Correlation and scatter in statistical variables. *Nordic Statistical Journal*, Vol. 1, pp. 36–102, 1929.

GIBBS, R. W. M. The Adjustment of Errors in Practical Science. *New York and London* (Oxford University Press), 1929. Pp. 112. 4¾ × 7¼ inches. $1.75.

LATTA, ROBERT, and ALEXANDER MACBEATH. The Elements of Logic. *New York* (The Macmillan Co.), 1929. Pp. viii + 393. 4¾ × 7¼ inches. $2.00.

MINER, JOHN R. A Review of "Studies in the History of Statistical Method with Special Reference to Certain Educational Problems," by Helen M. Walker. Baltimore, The Williams and Wilkins Company, 1929, viii + 229 pp. *Journal of the American Statistical Association*, Vol. 25, No. 169, pp. 113–114, 1930.

PLOTNIKOW, IVAN. Photochemische Arbeitsmethoden im Dienste der Biologie. Handbuch der biologischen Arbeitsmethoden. Lieferung 323. *Berlin* (Urban und Schwarzenberg), 1930. Pp. 260. 7 × 10 inches. 13 marks (paper).

SHOHAT, J. (JACQUES CHOKHATE). Inequalities for moments of frequency functions and for various statistical constants. *Biometrika*, Vol. XXI, Parts 1 to 4, pp. 361–375, 1929.

SMITH, DAVID E. A Source Book in Mathematics. *New York* (McGraw Hill Book Co., Inc.), 1929. Pp. xvii + 701. 5¾ × 9 inches. $5.00.

TSCHACHOTIN, S. Rationelle Organisation von biologischen Instituten, und Rationelle Technik der geistigen Arbeit des Forschers. Handbuch der biologischen Arbeitsmethoden. Lieferung 318. *Berlin* (Urban und Schwarzenberg), 1930. Pp. 106. 7 × 10 inches. 6.60 marks (paper).

WISHART, JOHN. Le traitement correct des problèmes de corrélation multiple en météorologie et en agriculture. *Association Française pour l'Avancement des Sciences. Congrès de la Rochelle* (1928) *Paris*. 4 pp.

VIII. MISCELLANEOUS

BOLLETTINO DELL' ASSOCIAZIONE INTERNAZIONALE DEGLI STUDI MEDITERRANEI. Anno I, Num. 1, Marzo, 1930. *Roma* (Associazione Internazionale degli Studi Mediterranei). Pp. 1–32.

INTERNATIONAL MEDITERRANEAN RESEARCH ASSOCIATION OF ROME. Report on the Proceedings for the constitution. "L' Universale" Tipografia Poliglotta, *Roma*, 1930. 35 pp.

MARMER, H. A. The Sea. *New York* (D. Appleton and Co.) 1930. Pp. x + 312. 5⅛ × 8 inches. $3.00.

PLUNKETT, CHARLES R. Outlines of Modern Biology. *New York* (Henry Holt and Co., Inc.), 1930. Pp. vii + 711. 5⅜ × 8½ inches. $3.75.

SCOTT, GEORGE G. The Science of Biology. Revised Edition. *New York* (Thomas Y. Crowell Co.), 1930. Pp. xx + 633. 5⅝ × 8⅜ inches. $3.75.

SLOSSON, EDWIN E. Short Talks on Science. *New York* (The Century Co.), 1930. Pp. xii + 281. 5 × 7¼ inches. $2.00.

WOODRUFF, LORANDE L. Foundations in Biology. Fourth Edition. *New York* (The Macmillan Co.), 1930. Pp. xvi + 501. 5½ × 8½ inches. $3.50.

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